# AFRL-ML-WP-TR-2004-4161

# VALIDATING ADVANCED SUPPLY-CHAIN TECHNOLOGY (VAST)

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**AIR FORCE RESEARCH LABORATORY**
**AIR FORCE MATERIEL COMMAND**
**WRIGHT-PATTERSON AIR FORCE BASE, OH 45433-7750**

# NOTICE



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The purpose of the Validating Advanced Supply-chain Technology (VAST) program was to help drive affordability concepts throughout the defense industrial supplier base by validating and stimulating improvement in small and medium sized enterprises (SME) as a result of supplier development initiatives. The VAST Program focused on two technology activities for SME supplier improvement: 1) On the utilization of the principles embodied in Lean Deployment at the SME, and 2) Digital communication of the Technical Data Package (TDP) data to the SME. The program was able to complete work with one supplier in the Lean and STEPwise technology areas. The results indicate that the return from a single prime contractor perspective is marginal while the broader payback to the Defense Industrial Base and the DoD provides a significant return on investment.

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# Executive Summary

## 1.1 Technical Summary

The purpose of the Validating Advanced Supply-chain Technology (VAST) program was to help drive affordability concepts throughout the defense industrial supplier base by validating and stimulating improvement in small and medium sized enterprises (SME) as a result of supplier development initiatives. The validation of affordability concepts focused on the development of the business case for suppliers. The stimulation of affordability improvements focused on gainsharing for all parties involved – Air Force, F/A-22 Program Office, prime contractors, sub-contractors – including the SMEs. The VAST Program focused on two technology activities for SME supplier improvement: 1) On the utilization of the principles embodied in Lean Deployment at the SME, and 2) Digital communication of the Technical Data Package (TDP) data to the SME. Working with the F/A-22 System Program Office, the program addressed key issues facing the Air Force in an era of increased outsourcing and reliance on supplier capabilities, and increasing emphasis on affordability.

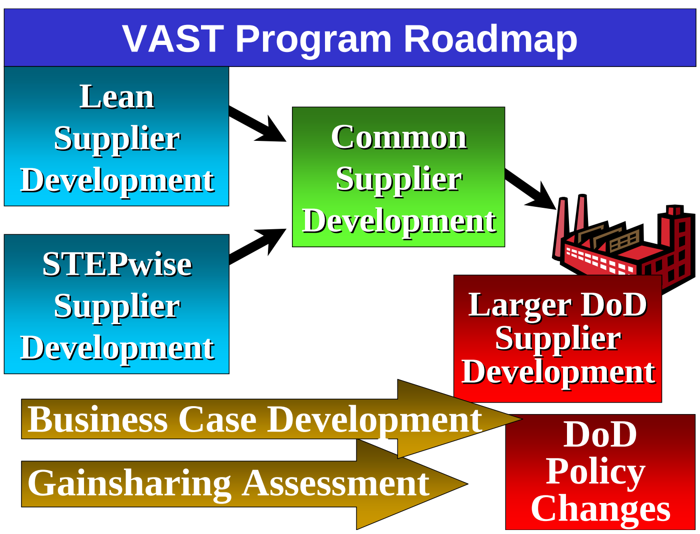



**Figure 1. VAST Program Roadmap**

The original VAST Program was proposed as a three phase program that is summarized in Figure 1 VAST Program Roadmap. The first phase focused on an initial engagement of a set of third tier suppliers to foster Lean Development activities and a set of Build-to-Print Suppliers for STEPwise (TDP data to supplier). As part of the first phase, the Business Case and Gainsharing Assessments would provide the information for validating and stimulating the SME suppliers. The second phase of the program proposed to build upon the Lessons Learned in the first phase and engage additional Lean and STEPwise suppliers to refine the recommendations from the first phase. The final phase of the program proposed to provide recommendations relative to development in the larger DoD supplier base and DoD Policy Changes. Unfortunately, due to funding reductions the VAST team was not able to complete all planned phases of the program. Although the effort was descoped, the program was able to complete work with one supplier in the Lean and STEPwise technology areas, provide business cases for these suppliers, and develop gainsharing and deployment recommendations.

The STEPwise business case identified a 44% cycle time reduction and over $25,000/year cost avoidance for the F/A-22 Program and $232,000/year for all LM Aero business with for the single VAST supplier. The selected supplier provides Build-to-Package (BTP) sheet metal parts

for the F/A-22 program and provides similar parts to LM Aero on a total of five fighter programs. The selected VAST supplier is one of sixty-three identified BTP sheet metal suppliers supporting F/A-22 production. When these cost avoidances are taken across the entire LM Aero F/A-22 SME Build-to-Package business base, the results are over $1,000,000/year cost avoidance for the F/A-22 Program. While these results may be insignificant when taken in the context of a single SME, when taken across the broader F/A-22 SME base or the larger DoD SME base, the results are significant.

The VAST team captured metrics and documented results for a single lower tier SME supplier for a Kaizen Event conducted on the setup reduction process. The team identified a 68% reduction in setup cycle time and over $33,000/year in cost avoidance for a single F/A-22 part. Projections over the duration of the current F/A-22 Program estimate of aircraft production for this single part identified approximately $400,000 cost avoidance for the entire program for the single Lean supplier on this part. Details of both Business Cases are documented with each technology area addressed and can be found in that respective section of this report.

The VAST Program documented several approaches to Gainsharing that are available within industry. Each of these gainsharing approaches can provide an organization with methods to stimulate the suppliers to drive affordability concepts. Gainsharing can be categorized into two broad categories: a Project Type approach (e.g., Value Engineering, Kaizen, Group Purchase Agreement) and a Sharing Strategy approach (e.g., Memorandum of Agreement, Negotiation, 50/50). The VAST Program also identified several impediments (e.g., Truth In Negotiations Act - TINA) to gainsharing that will continue to impede driving affordability concepts through the SME arena. Details of these are contained in the Gainsharing Section of this document.

## 1.2 Program Management Summary

The original VAST team consisted of Advanced Technology Institute (ATI), Lockheed Martin Aeronautics Company, Arthur D. Little, Inc., Integrated Support Systems, Inc. (ISS), and Spatial Technologies. Due to consolidations Spatial Technologies was replaced with Theorem Solutions and Arthur D. Little, Inc. was replaced with expertise from ATI.

The original program was proposed to be a little over $2 million with a 50% match from the participating companies - $3 million total program value. Due to Air Force funding issues, the final program budget was reduced to $825K while maintaining a little under 16% industry match - $960K total program value. Despite this, the program results are of value.

It is unlikely that the VAST program would have been funded by Industry due to the nature of risk involved with small return on investment on a per supplier basis. While this may appear to be shortsighted, many of the SMEs provide products or services to multiple DoD contractors who are often competitors. The VAST results indicate that the return from driving these affordability concepts from a single prime contractor perspective is marginal, while the broader payback to the Defense Industrial Base and the DoD provides a return on investment that becomes significant.

# 2 Introduction

## 2.1 Background

The VAST Program was submitted as a proposal to AFRL/MLMS in May 1999 in response to the Small & Medium Enterprise (SME) Initiative Program[i]. The VAST program objective, under the broader SME Initiative, was to demonstrate advanced supplier development concepts with suppliers and to validate the benefits of this interaction. DoD Program cost cutting initiatives are creating a continuing pressure for contractors to provide goods and services better, faster and cheaper. Adopting advanced supplier development concepts including "lean" manufacturing and STEPwise information exchange were recognized as mechanisms that will enable the SMEs to meet these pressures.

## 2.2 Statement of Need

The SME Initiative Program resulted from several AFRL/MLMT workshops to help in the definition of the SME program requirements based upon DoD, Air Force Weapon System Program Office, and DoD Industrial Base needs[ii,iii]. The following sections are a summary of the issues that the VAST Program addressed.

### 2.2.1 Supplier Influence on Weapon System Affordability

The affordability of weapons systems increasingly depends on the capability of the supply base, some of which is comprised of small companies. This is being driven by the lower number of weapon system platforms that are being procured. To improve competitiveness, most prime contractors of weapons systems platforms and subsystems have moved to retain only core competencies for design and integration of the components. They now outsource most detail part fabrication and some assembly. In terms of manufacturing, most large aircraft weapon system companies only produce subassemblies and assemble the final product.

AFRL research has shown that over 80 percent of the value of some weapons systems is supplied, and the percentage is nearly that for most subsystems. For the F/A-22 Program, approximately 31% of the cost is in the 2$^{nd}$ tier suppliers.

### 2.2.2 Supplier Capabilities

Typically small companies do not possess the capabilities of the larger contractors for sustained research, development, and technological implementation. One of the goals of the VAST Program was to address methods for stimulating the development of the smaller companies. The SME Program Initiative identified some key capability indicators as a function of company size and identified the primary reasons for this capability gap between smaller and larger companies is the lack of financial and technical resources. The capability gap is widening since the pace of improvement seems much slower in the smaller firms than in larger manufacturers. The SME Initiative program was responding to a high and steadily increasing dependence on these smaller companies.

### 2.2.3 Developing Suppliers

It is well known that many world-class commercial companies pursue aggressive, continuing activities with their suppliers to help them improve in all areas of their business – management, financial and technical. The VAST team identified examples wherein a world-class customer and

supplier have developed a close relationship for over a period of years. Throughout that time, integrated customer/supplier teams worked to improve business and technical processes at the supplier and at the customer. Most of these companies regularly practicing supplier development not only permit their suppliers to offer their improved capabilities to other customers including competitors, they advertise it. They believe this will help the supplier be a stronger company, and stronger suppliers will be more responsive to their own needs.

One of the critical needs identified is the need to redesign customer firm practices and organizational principles to enable a supplier development program. Top-level supply base management culture should include customer and supplier executive involvement to ensure success. Supply base consolidations, which are a natural offshoot of examining organization of the supply chain management function, can also be used as opportunities to develop supplier development plans. Government (Local/State/Federal) coalitions have been successfully formed to subsidize supplier development providing funding for expertise.

ATI selected Lockheed Martin as the prime contractor representative on the VAST program based on the Lockheed Martin Aero recognition of the importance of supplier development and their strategy for improving the overall performance of their suppliers. Lockheed Martin supports the philosophy that stronger, more capable suppliers make the entire enterprise more competitive by lowering total cost and allow them to be more responsive to the needs of their customers.

Because LM Aero also provides a variety of aircraft to DoD, their participation in the VAST program provided a basis for extrapolating the business case results across the wider DoD industrial base. Figure2 shows the breadth of the Lockheed Martin Aeronautics Sector support.


**Figure 2. Lockheed Martin Aeronautics Sector Programs**.

## *2.3 VAST Program Goals*

The VAST Program focused on two technology activities for SME supplier improvement: 1) On the utilization of the principles embodied in Lean Deployment at the SME, and 2) Digital communication of the Technical Data Package (TDP) data to the SME. The first initiative, denoted as Lean Supply Chain Development, is typically focused on the highest dollar volume suppliers. The VAST Program stretched the current 1st tier large supplier development activities to the SME (2nd tier) arena, where significant benefits resulted. The VAST Team validated the business case of Lean Deployment with one 2nd Tier SME supplier. The program originally targeted four SMEs at the 2$^{nd}$ Tier, but funding precluded executing with those additional suppliers. The SME underwent a Lean Engagement process that included:

1) Lean Awareness Training,
2) Development of a Continuous Improvement Plan,
3) Kaizen events to introduce the Lean process to the SME, and
4) Business case validation for the targeted Lean Deployment activities.

Details of this Engagement are included in the following sections of this document.

The VAST Lean supplier development initiative focuses primarily on streamlining core functions within a supplier's organization. The program has also undertaken supplier development through data exchange capability enhancement and automation. VAST team members ATI, LM Aero, ISS, and Theorem Solution demonstrated how suppliers can electronically receive, review, and process standard technical data packages (TDP) for responding to request for quotes (RFQs) and for Purchase Orders (Pos). Called STEPwise, this process addresses data transfer of 'build to packages' from Lockheed Martin to 1st Tier suppliers of sheet metal and machined parts.

A key element of STEPwise is the utilization of the ISO 10303 standard for exchanging technical data. A portion of this specification evolved from a highly successful Air Force WPAFB/WL/ManTech sponsored program called PDES Application Protocol Suite for Composites (PAS-C). The broader standard is also being use in other defense companies, such as Boeing, Northrop Grumman (a STEPwise participant), and Rockwell, as well as other commercial companies, such as GM, Ford, and IBM. In addition, the DARPA-sponsored STAMP program, led by ATI, is piloting the specification with a Raytheon missile supply chain. These efforts promote solutions that allow a supplier to exchange and manage technical data from multiple customers using a single system.

# 3 VAST Suppliers Lean Development

## 3.1 Why Lean in the Supply Chain?

Most manufacturing systems are characterized by a high degree of waste. In Lean Manufacturing these wastes are defined as: overproduction, transportation, waiting, motion, processing, inventory and defects. Lean Manufacturing is the current best practice approach to this problem. To date, most Lean Manufacturing efforts have focused on the internal operations of an individual plant. However, much of the waste seen in an individual plant has its roots in the larger supply network. For example, a customer may place large batch orders at irregular times, which cause suppliers to maintain high levels of inventory in order to meet the unpredictable order flow. An examination of just the supplier would reveal high levels of inventory, but would provide no means of understanding or dealing with the cause of problem.

The level of supply network waste produced by these problems is difficult to estimate. James Womack, author of "The Machine that Changed the World and Lean Thinking", estimates that internally focused Lean interventions can eliminate 25% of wasted steps and improve throughput time by 50%. He argues that a further 75% of wasted steps could be eliminated and that throughput time could be reduced by 90% by working on the entire value stream in the supply network.

The VAST team adopted the Lean concepts and built on Lockheed Martin Aero efforts with their first tier suppliers to extend the benefits of Lean to lower tier suppliers. Lockheed's commitment to Lean is summarized in the following statement by Mike Walters, Vice President of Material Management.

***"In the 21st century, there will be two kinds of companies: competitive and closed."***

Lean Manufacturing is a strategic choice for businesses facing serious competition. It is now widely recognized that companies who have mastered Lean methods will enjoy substantial cost and quality advantages over those that are still practicing large-scale production. Day after day, companies using flow manufacturing techniques are radically reshaping the industry – breaking barriers once thought impenetrable as they strive to become demand-driven and gain a competitive edge. These are the companies that will survive and prosper in the coming millennium.

By embracing Lean principles, companies throughout the supply chain provide unparalleled responsiveness and flexibility by predictably and consistently synchronizing single-piece or small lot flows of product through their factories. This is accomplished by demanding exacting levels of quality process control, standardizing the most waste-free fabrication and assembly methods possible, and managing the totality of manufacturing processes as a complete production system to deliver the highest levels of customer value.

Undoubtedly, improvements and inventive techniques will add new chapters to the chronicle of Lean advances, but the fundamental approach will illuminate the path to world-class manufacturing for the foreseeable future. What is abundantly clear now is that the manufacturing methods we grew up with will not carry us into the future. The choice is simple: improve or die.

Mike Walters
Vice President/Material Management

**Figure 3. Lockheed Martin Commitment to Lean**

Lockheed Martin Aeronautics emphasizes that, since suppliers are responsible for 60-70 percent of the cost of today's aircraft (with approximately 31% of the F/A-22 costs in the second and lower tier suppliers), they along with LM must work together as a team in leaning out processes to provide value to the customer. The VAST efforts to bring Lean concepts to the SME's in the lower tiers of the F/A-22 supply chain built on this approach.

## 3.2 Goals of VAST Lean Supplier Development Activities

The VAST program's primary goal was to validate the benefit of implementing Lean practices in SME's who have been identified as making up a significant portion of the F/A-22 supply chain. Traditionally, SMEs don't constitute a large enough base of business to justify resources to implement Lean. Furthermore, these lower tier suppliers do not typically have the resources for acquiring outside Lean experts or devoting an internal staff to Lean deployment. The VAST approach included conducting the necessary Lean training for the selected Lean suppliers and the development of a business case for SME companies based on promoting Lean initiatives as a routine business practice. The methodology for migrating Lean principles to the VAST SME's closely followed the LM Aero Lean Supply Chain Management approach for 1st Tier suppliers depicted in the figure below, taking into account similarities and differences.

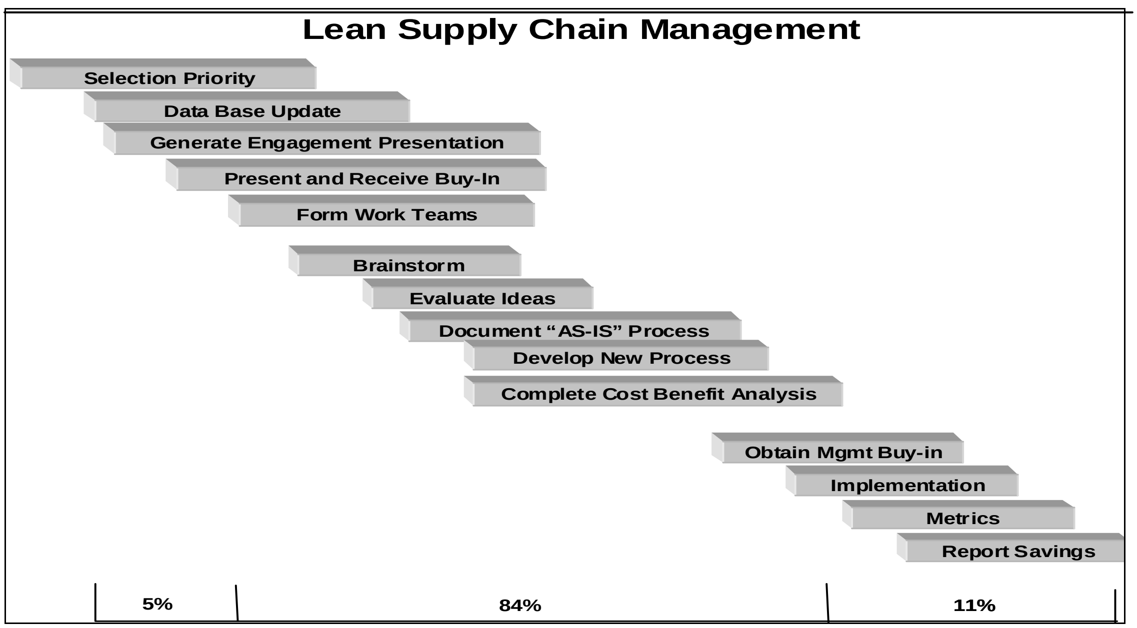



**Figure 4. Lean Supplier Development**

A key objective of the VAST Lean Deployment was to reduce costs through eliminating non value-added activities, or waste. In-depth training was provided to SMEs to develop continuous improvement teams that focus on the workflow and the methods for streamlining and standardizing processes with the desired result of reduced variability in processes and a reduction of excessive movement of employees, hardware and office output. The workplace environment was also considered leading to a primary focus to simplify the work and provide quick, visual references of the overall status and flow of the parts through the production processes.

One of the major tenets of Lean is one-piece flow. Once these principles are in place and the processes are stabilized, it is possible to begin introducing proactive ways to achieve continuous improvement. To implement one-piece flow, systemic changes are required in the method and timing of material provided by suppliers and the processes used on the factory floor.

The final step toward Lean is perfecting all processes so one piece of material is pulled by a manufacturing requirement and delivered to each step in the process as it is needed. The interaction of workers and machines must also be choreographed to achieve optimum flow. The last step includes the automation of material handling for loading and unloading machines.

## *3.3 VAST Approach to Lean Supplier Development*

One of the first activities undertaken by the VAST team was to identify and gain the commitment of the SME's who would participate in the VAST program. In the supply chain, direct relationships only exist from one level to the next. As such, LM Areo maintains a contractual relationship with their first tier suppliers, but has no direct or contractual link to second, third, and lower tier suppliers. To overcome this, LM Aero first tier suppliers were identified who in turn could identify F/A-22 second tier suppliers to participate. Figure 5 depicts this relationship.

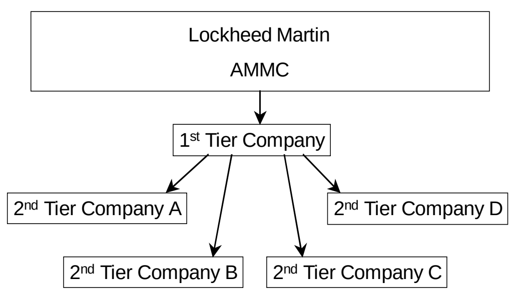



**Figure 5. Lean through the Supply Chain**

The VAST team developed a set of supplier selection discriminators to determine which SMEs would be viable candidates for participation in the program. The selection discriminator mandated that first tier suppliers could not include companies with significant delivery or technical problems with immediate program impact. A prioritized list of the first tier suppliers who would offer the greatest return to Aeronautics Sector customers was compiled by the VAST team. With the list of potential F/A-22 first tier suppliers in hand; the supplier's senior management was then contacted to determine their willingness to participate and to obtain formal VAST program participation commitment. The responsibility of the selected 1$^{st}$ tier supplier was to identify their 2$^{nd}$ tier suppliers for potential VAST program participation and to commit to participate in the gainsharing portions of the project.

The Vast team also developed a set of discriminators for the proposed 2$^{nd}$ tier suppliers. SME's were sought who were currently under contract to provide F/A-22 parts, and could be considered as "a typical F/A-22 SME supplier" in that they held core competencies including aircraft machined parts, structural and mechanical assemblies and who utilize a number of process, procedures and systems in their daily business. Like the 1$^{st}$ tier suppliers, once selected, the 2$^{nd}$

tier supplier's senior management was contacted to determine their willingness to participate and to obtain formal VAST program participation commitment.

VAST team members conducted an on-site assessment of the SME's Lean maturity. Once the areas of opportunities were determined and a Continuous Improvement Plan created, the selected SME supplier received in-depth Lean training followed by a series of continuous improvement events over the course of the VAST program. The Lean events included Value Stream Mapping and Kaizen Events designed to reduce cost through waste elimination and process improvements. Metrics were established and data was collected forming the basis for the VAST business case.

### 3.3.1 VAST Lean Supplier Profile

The SME selected to participate in the VAST program was a middle-tier, certified, small, disadvantaged businesses. Their facilities are modern air-conditioned buildings with machinery capable of producing the most challenging structural machined configurations in aluminum, steel, titanium, and inconel. The majority of their business (over 80%) is in providing machined parts for DoD products for a variety of customers including Boeing Aerospace & Electronics, Boeing Commercial Airplane, Boeing Military Airplane, Boeing Helicopter, Lockheed Martin Aerospace, Sikorsky Aircraft, Northrop Grumman Corporation, and Goodrich. They are a fairly typical small machine shop in the DoD industrial base.

Lean Supplier Profile:

- Founded in 1969
- Approximately 76,000 Sq feet on seven acres
- Certified small disadvantaged business
- Approximately 130 employees
- Core competency: Aircraft Machined Parts, Structural and Mechanical Assemblies
- Producer of the most challenging structural machined configurations for demanding customers in Aluminum, steel, titanium, and inconel.
- Contains over 19 principle machines
- Products for F/A-22, C-17, 767, EA6B, UH60, S76, and 757.
- Customers include Boeing Aerospace & Electronics, Boeing Commercial Airplane, Boeing Military Airplane, Boeing Helicopter, Lockheed Martin Aerospace, Sikorsky Aircraft, Northrop Grumman Corporation, and Goodrich.
- Maintains business/engineering/inspection systems; NCL, CATIA, DEA PC DMIS (CMM), Enterprise Chain Business System with MRP

### 3.3.2 VAST Lean Selected F/A-22 Parts

The VAST team evaluated components fabricated by the participating suppliers for the F/A-22. The selected parts were based on a decision reached jointly between the VAST team and the Lockheed Martin Aeronautics first and second tier suppliers. The first tier supplier contracts with Lockheed Martin Aero to provide the AMRAAM missile Vertical Ejection Launcher (AVEL) units for the F/A-22. The VAST SME provided the Lower Beam, Upper Beam, and Link Arm components through a contract with the first tier supplier. The F/A-22 Lower Beam of the AMRAAM missile Vertical Ejection Launcher was selected as the primary part used in the VAST program. The main driving force behind the supplier's particular selection was their

executive management had previously agreed to a 20% price reduction on the most complex parts they manufacture. From the supplier's perspective, the VAST Program was the vehicle to help them achieve process savings to meet the agreed upon price reductions.

### 3.3.3 Supplier Training

The VAST team conducted Lean Supplier training for the participating SME focused on basic principles of Lean and how the SME's could apply the principles within their manufacturing workplaces. Definitions of Lean terms were provided and the context to which they were to be used in the coming Value Stream Mapping Event.

Lean principles:

- Precisely Specify Value By Product
- Identify Value Stream For Each Product
- Make Value Flow Without Interruptions
- Let Customer Pull Value From The Product
- Pursue Perfection

The training included a context setting demonstration of Lean concepts using a mock bracket manufacturing company. The sample illustrated the migration from a "typical" manufacturing process to one where Lean ideas where implemented. Lead time, productivity, work-in-process, scrap, and space metrics where collected and reviewed at the end of the exercise. The results revealed how small Lean modifications within the manufacturing process will yield great benefit and savings. Ultimately the training exercise ended with a complete Leaned process and the final potential savings that could be reached. The full training agenda is shown in Figure 6.

| First Week (2 days) | Second Week (5 days) |
|---|---|
| Kickoff<br>Management participation<br>Agreement on goals and metrics<br>Overview of Lean principles<br><br>Training - Lean Techniques<br>Presentation<br>Video<br>Simulation<br>Review of applicable data forms and worksheets | Day One<br>"As is" value stream mapping<br>Time/value analysis<br>6s evaluation<br>Day Two<br>Brainstorm screen ideas<br>"To be" value stream mapping<br>Day Three<br>Simulation<br>Refine "to be" process<br>Day Four<br>Implement change<br>Day Five<br>Quantify Improvement<br>Debrief supplier management |

**Figure 6. VAST SME Training Agenda**

The SME training continued with a Value Stream Mapping session to help determine areas of waste and identify opportunities for improvement within their manufacturing processes. A sample Value Stream Map output is depicted in Figure 7 below. At the end of the mapping exercise, a continuous improvement plan was developed that outlined the potential improvement areas and scheduled Kaizen events to address these areas.

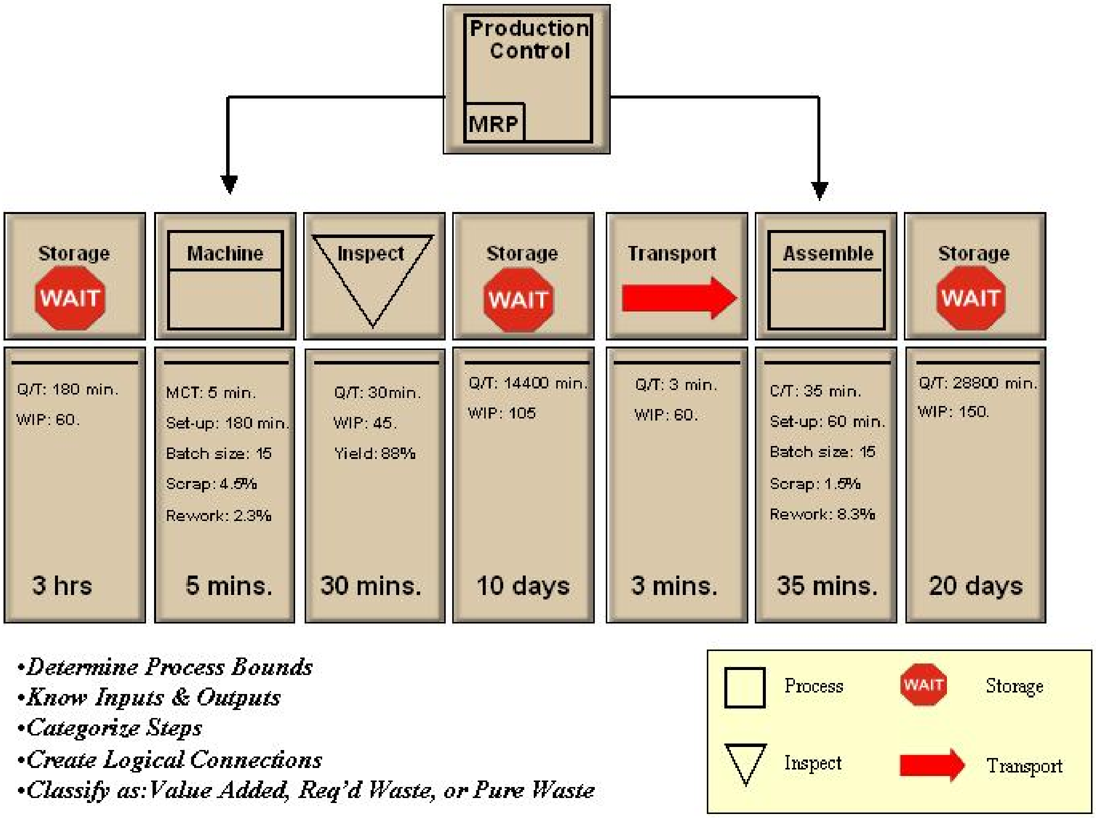



**Figure 7. Sample Value Stream Mapping Output**

Following the completion of the Value Stream Mapping, exercises called Kaizen Events were conducted which required the supplier to identify and make actual changes within their manufacturing processes in an effort to realize savings and cycle time reductions. The results from the Kaizen Events were documented and validated against the perceived benefits identified during the original mapping session. This data was used as the foundation for the VAST business case.

### 3.3.4 Value Stream Mapping Events

There are three primary value streams addressed within a Value Stream Mapping event.

- *Technical problem solving* addresses the product and manufacturing engineering from product concept to initial production. Technical problem solving defines the product, the quality systems and determines the manufacturing processes to be used in the making of the product.
- *Information flow* encompasses all aspects of the management of information from order taking to customer delivery. From shop floor and transactional controls to kanban and Enterprise Resource Planning, Information flow addresses every system that tracks or generates data.
- *Product flow* addresses the factory floor. It includes the systems used to manufacture the product and the interaction of employees and machines.

There were a total of 3 Value Stream Mapping events conducted with the VAST SME. The first VSM focused on the Lower Beam of the F/A-22 AMRAAM Vertical Ejection Launcher assembly. The Lower Beam (shown in Figure 8 below) is the flat piece attached directly to the missile body. The study shared high-level information on the product and the context of how it is to be

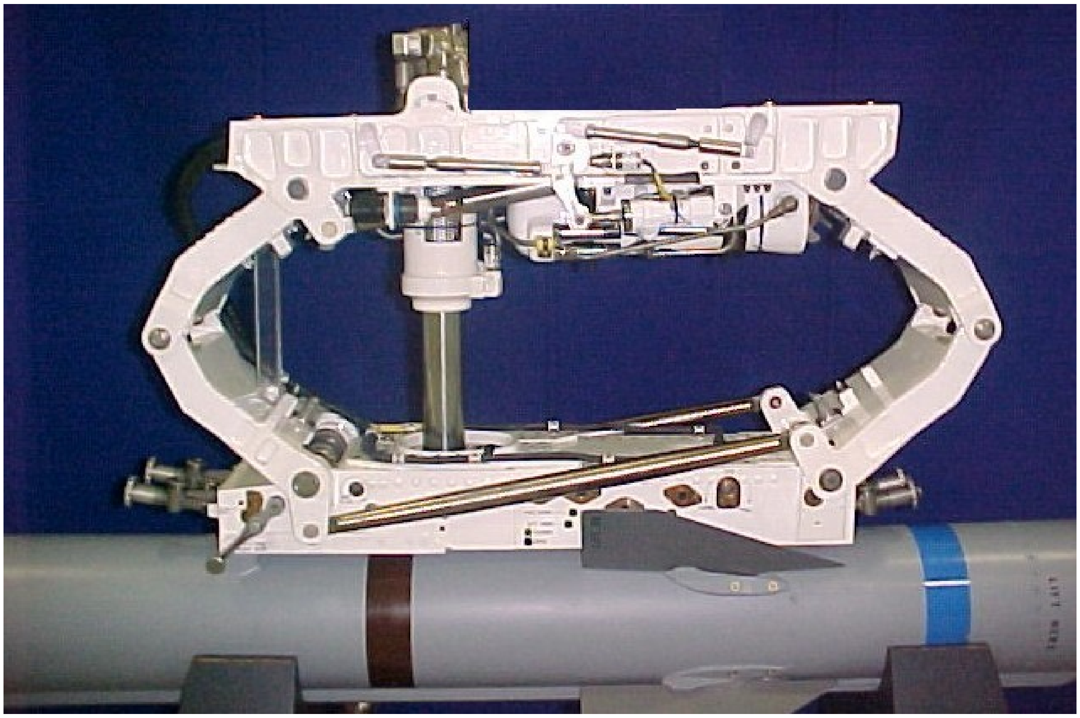
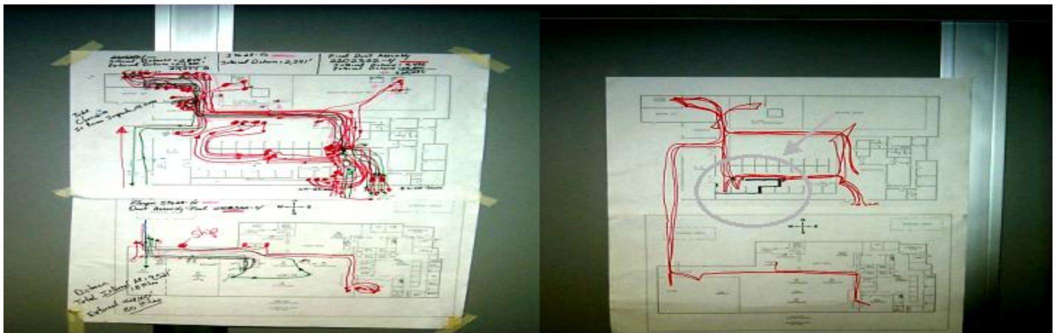


**Figure 8. Lower Beam**

used in the F/A-22 aircraft. The study also examined technical and specific details on the parts manufacturing processes.

Within the manufacturing process, all individual steps were identified. All the associated waits, moves, set-up, and manufacturing durations were utilized to determine the part's lead-time. Each process step was carefully considered and assigned a label of 'value added', 'non-value added', or 'waste' and then segregated into separate categories. The respective categories were entered into a table and percentages calculated based against total production time to recognize the true picture of what was actually 'value-added'. The VAST team worked with the SME representatives to determined areas where Lean principles were to be applied and the potential savings from that effort. The top three of these groups became the focus manufacturing processes and became the basis for the subsequent Kaizen Events.

The team also constructed a "spaghetti diagram" showing how far the part actually traveled within the supplier facilities. Each production step was physically walked and distances calculated. Figure 9 shows the spaghetti diagram, the final travel calculations and the potential improvement to reduce travel time and improve process flow.



| | Before | After | % Reduce |
|---|---|---|---|
| Total Lead Time | 7 weeks | 3 weeks | 65 % |
| Cycle Time | 8 hours | 6 hours | 25 % |
| Part Travel (ft.) | 2,450 ft | 1,578 ft | 36% |
| Walking (ft.) | 3,150 ft | 1,578 ft | 50% |
| WIP | 360 pcs. | 200 pcs. | 44% |

**Figure 9. Spaghetti Diagram**

| Lean Supplier – Spaghetti Diagam ( Distance Traveled between Processes) Final Calculations | |
|---|---|
| Stage 5 | 5070 |
| Stage 3 | 7710 |
| Final Assembly | 1140 |
| Total Distance in Feet | 13,920 |
| *Distance in Miles* | *2.64* |

**Figure 10. Lean Supplier Final Travel Calculations**

Figure 10 represents the total distance traveled within the supplier's production facility. The part was tracked from its initial receipt into the facility to final shipping to their customer. Distance was first calculated in feet and then transferred to miles. This exercise is used to help educate the supplier on how far a part does actually travel within their facility. A spaghetti diagram is drawn to help the supplier visualize the actual movement of the part. From this diagram, supplier management can make educated decisions on moving machinery in an effort to achieve a cellular manufacturing goal.

The VAST team, at the request of the SME, conducted the remaining two VSM events based on their recognition of the value obtained from the initial VSM on the AVEL Lower Beam component. The parts selected for these VSM's were the AVEL Upper Beam, and Link Arms are shown in Figure 11.

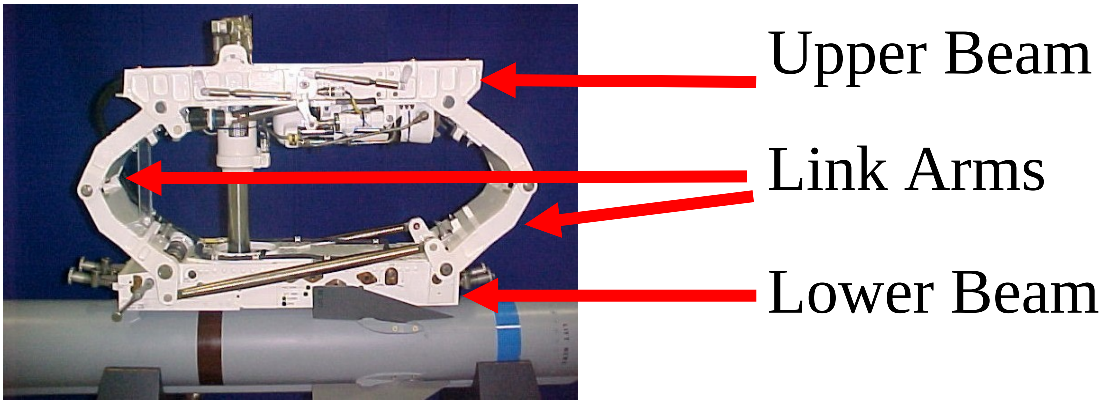



**Figure 11. AVEL Upper Beam, Lower Beam, and Link Arms**

VSM metric spreadsheets were created and divided into conventional/non-conventional machinery to help the supplier's management see how the processing time is spread. Additionally, ideas were provided to the Lean Supplier to help identify areas of improvement. Unfortunately, these could not be implemental during this VSM event due to limited VAST funding. However, the SME agreed to conduct their own Kaizen Events for these other two parts based on the findings and spaghetti diagrams of the VSM's events.

The SME currently outsources the fabrication of both the AVEL upper beam and link arms. After they perform the Kaizen Events for these two parts, they may be able to bring the fabrication back in-house. Their near-term goal is to begin producing some of the upper beam and link arms parts in parallel with the outsourced parts. This would allow the Lean Supplier to reduce, not eliminate, the number of parts outsourced and meet their ultimate customer (i.e., F/A-22 program) needs.

Figure 12 details the analysis from the original Value Stream Mapping Event. The team reviewed ideas on how to improve internal processes. Similar ideas were grouped and ranked in order of importance to the supplier. The top three ideas were categorized as candidates for future Kaizen Events.

| Lean Supplier<br>Lean Brainstorming Session and Groupings | |
|---|---|
| **Brainstorming Ideas** | **Grouping** |
| a. Move some work from Dixi machine to other compatible machines | (1) |
| b. Review requirements for the following: Radii, Tolerance, Key Slot, and Side Joggle (*Lean Supplier- to review with their customer)* | (2) |
| c. Make rather than buy force-mate bushings | (3) |
| d. Right Angle head operations: *identify, possibly dedicate Bridgeport operations, flow enhancements* | (1) |
| e. Balance machine times | (1) |
| f. Develop standard work placards (set-up & production) | (4) |
| g. Continuous Bridgeport operations | (1) |
| h. Honing: *preset mandrels, shadow-box tools, ring gauges* | (5) |
| i. Bridgeport – implement two shift operations | (1) |
| j. CNC's – look into set-up reduction | (6) |
| k. Add NC mill operation to bushing flanges | (1) |
| l. Utilization of and alternate 'Paint House' (currently ACT): *Top coat, process, primer, alodine* | (7) |
| m. Building door: *move machines and create a new opening to cut down on travel distances* | (8) |
| n. Review information flow | (9) |
| o. Possible Kaizen Events: *Shipping Department, Assembly Department, Deburring* | (10) |

**Figure 12. Lean Supplier Brainstorming Session**

The supplier used the VSM techniques to identify additional process improvements. For example, the supplier built four additional fixtures to allow one-piece flow on the Bridgeport milling machines. Additional work improved the Computer Numerical Controlled (CNC) fixtures and programming to eliminate unnecessary honing steps. The mapping technique "opened their eyes", inspiring them to develop more efficient workflows using Lean techniques.

### 3.3.5 Kaizen Events

The supplier's executive management found it very valuable to their company to participate in Lean principles training. At the supplier's request a supplementary Lean training session was conducted for additional employees. The supplier also received instruction and participated in exercises for "6S evaluation". Table 1 provides and overview of "6S" principles.

**Table 1. Lean 6S Principles**

| | |
|---|---|
| Sort | Include only what is needed and get rid of clutter |
| Straighten | Organize the workplace, everything has it's place |
| Shine | Clean the work area and equipment |
| Standardize | One procedure for completing task |
| Sustain | Keep lean effort in areas continually going |
| Safety | Constant attention to workers surroundings |

The exercise involved sorting, straightening, and standardizing. Sorting proved to be very valuable as it removed a significant amount of "junk" from the assembly and storage rooms that had been designated as staging areas for kitting of parts. Straightening and standardization resulted in the creation of numerous "shadow boards" to organize assembly tools and tools used in the bearing/bushing installation process. To further enhance capabilities, a shadow boarding training session was provided to illustrate Lean techniques to improve their shadow boarding efforts.

Point-of-use techniques were demonstrated in the honing machine area by moving many frequently used tools to locations adjacent to the honing machines. This resulted reductions in "travel distance" as well as saving related to "finding part" times. The kitting process was reviewed which lead to setting-up the storage room as a staging area for kits and identified the need for a reduction in kit sizes that were delivered to the assembly floor. This reduced amount of Work In Process (WIP) held in the immediate assembly area.

A list of action items brainstormed with the Lean Supplier is shown below. The supplier worked these items internally because they recognized the value of the Lean principles.

Brainstorming action items:

- Determine kitting concept for optimum kit size and short kits
- Determine whether other stock room will be merged with new kit room
- Make schedules for 'repeating jobs' available to assembly supervision
- Tool home location labeling
- Continue bearing/bushing shadow boarding
- Continue assembly tooling shadow boarding
- Determine 'EDO numbering' style for Sikorsky jobs
- Develop 6S sustaining procedure

**Figure 13. Action Items Brainstorm**

A second Kaizen Event was conducted with the Lean Supplier, which focused on the machine setup of a CNC mill used on the F22 AMRAAM missile Vertical Ejection Launcher (AVEL) lower beam. Objectives of the event covered:

- Determining the current state of the machining process,
- Identifying the proposed future state, and
- Identifying the methodology used to achieve this future state.

Value Stream Mapping Operation #60 on Mazak 3 (shown in Figure 14 below) was chosen as the machine setup to analyze in this event. Setup reduction benefits that were identified included:

- Lower throughput time
- Equipment utilization
- Build to requirements, not stock, and
- Reduction in setup complexity issues


**Figure 14. MAZAK 3 Machine**

The VAST team videotaped the current state processes and reviewed it with the machine operator. The process steps were documented, and then a brainstorming session took place to determine needed process improvements. After the process improvements were incorporated, the setup was videotaped again to document the future state. A different operator, but of equal labor grade, was used to do the future state setup. The team suggested that this would be a more convincing demonstration of the setup reduction process. The team viewed the video with process steps documented. Additional potential benefits were identified as: standardization of

processes for program downloading, standardization of hole probing techniques, and improvements to techniques related to the installation of T-nuts.

In addition to the VAST team, two SME machine shop lead-men and one manufacturing engineer also attended the out briefing. The event's outcome was well received by the supplier's President. Out brief comments focused on the importance of institutionalizing the improvement techniques by the "leaders" within the company and the value that these improvements would make to the company's competitiveness.

The Kaizen Event proved to be very successful in exposing the amount of systematic waste encountered in the supplier's setup process and in highlighting the benefits of making corrections. The SME immediately understood that reducing setup times can significantly decrease lead times on the manufacturing floor. Details of the savings and cycle time reductions are provided in the business case section of this report.

#### 3.3.6 Cultural Change

Lockheed Martin Aeronautics addresses cultural change throughout its business practices. At the supplier level, Lockheed Martin Aeronautics evaluates culture change by having the supplier choose which of the following statements best represent their level of addressing culture change:

- No attempt has been made to address culture change
- The need to address cultural change has been recognized and plans/tactics are being developed
- A culture change process has begun. Communication forums have been established. The need to change has been identified and communicated to the workforce. Floor level "change leaders" have been identified and are being educated on the need to change and how to effect change.
- Cultural change is apparent. "What's In It For Me" (WIIFM) has been addressed at all levels and is understood and accepted. Successes are recognized and rewarded accordingly.
- A continuous improvement (CI) culture exists. Employees recognize CI opportunities and enact positive change at all levels voluntarily and without management urging. Employees understand their level of empowerment to implement change.

Within the VAST SME, executive management is aware of the shrinking supplier base for DoD and commercial aircraft machined parts. They understand one key way to stay in business is to refine their internal processes to eliminate unnecessary wastes, which in turn will help drive down costs.

There were new supplier participants in attendance at each VAST Lean training, VSM events, and Kaizen Events. The SME is committed to implementing new procedures into their process. They are training as many people as possible to help educate their workforce on how they plan to operate in the future. This way key personnel within the manufacturing process can be trained in Lean techniques and spread this methodology throughout their specific department. Lean is traditionally a concept that is achieved in segments. Changes are made to the manufacturing process a little at a time to see the results and to help change the workers frame of mind from an

‘I’ve always done it this way’ attitude. Training numerous supplier personnel will reduce the time it takes workers to grasp and implement Lean techniques.

### 3.3.7 Use of VAST Concepts on Other DoD Parts

In an effort to reduce lead-time and find other opportunities for improvement on other DoD parts, the SME has applied Lean techniques to other areas of their manufacturing processes. On the day after the Setup Reduction Kaizen Event, the application of some of the lessons learned reduced setup time on an adjacent machine from 3 hours to 1 ½ hours. Additionally, the supplier took the initiative and used the Value Stream Mapping methodology on another DoD part. Although not part of the VAST project, the SME reported that significant savings were also realized in the set up areas for this part. It is considered a major accomplishment for the VAST program to learn that the SME is applying the VAST concepts and realizing savings on other DoD parts.

### 3.3.8 Benefit to Supplier

The true benefit of implementing Lean is the overall strengthening of the system. If applied properly the Lean methods will make any shortcomings in the system appear quickly. This will cause the problem to gain immediate attention, and a high level of importance will be placed on correcting the problem and installing permanent preventive measures.

Suppliers realize benefits in many ways, some quickly -- some long-term. Application of Lean methods is almost a directive for suppliers by Lockheed Martin Aeronautics. The benefits to the Lean Supplier was set when they agreed to 20-30% price reduction on some parts for their Lockheed Martin Aeronautics customer. Utilizing the Lean methods helps then to redefine their processes in order to meet this goal. With their Lean training experience, they are able to apply the same methodology to other DoD parts in an effort to reduce overall lead time to help develop opportunities for new or add-on business.

VAST participating suppliers are poised to increase their fabrication capacity without increasing their workforce. The additional capacity can be filled with new business or outsourced work can be brought back it with the corresponding improvement on lead-time. Lean methodology teaches suppliers what to do with their workforce and encourages them to re-deploy the skill set rather than layoff. This redeployment of personnel expands the workforce’s skill set by utilizing workers in other areas within the plant. A trained workforce is able to take on more responsibilities e.g., being able to operate more than one machine at a time. Furthermore, a trained workforce will realize the advantages of Lean and will be motivated to develop and implement ideas on their own for future process enhancements.

## 3.4 *VAST Lean Business Case*

### 3.4.1 Situational Assessment (Current State) and Problem Statement

The VAST program objective is to demonstrate advanced supplier development concepts with 2nd and lower tier suppliers and to validate the benefits of this interaction. Changing to utilize these advanced supplier development concepts including the concepts of "lean" manufacturing and STEPwise information exchange will enable the SMEs to meet cost cutting pressures. The following three scenarios adapted from Twiss provide motivation for SME change; [iv]

What could happen. Federal budget cuts could cripple the F/A-22 program resulting in less money for contractors and their suppliers. No SME contractors adopt the "lean philosophy". Depending upon the magnitude of these cuts, these contractors could lose their contracts and go bankrupt.

What will happen. Budget cuts. Prime contractors and 1st tier suppliers and some 2nd tier and 3rd tier (SME) suppliers go "lean" and reduce their costs. Others "forced" to work for less or go out of business. Customer (government, primary contractors, etc.) becomes more demanding and insists that contractors perform "better, cheaper, faster".

What should happen. Budget cuts. All primes and their suppliers go "lean" and manufacture better products in less time with lower costs.

The above scenarios are consistent with the current trends in the private sector.

### 3.4.2 Industry Trends

The VAST program adds another success story that attests to the power of the Lean Manufacturing philosophy. VAST also demonstrates that Lean methods combined with the STEPwise methodology are a powerful tool for reducing Air Force procurement costs. Furthermore, these Lean methods will increase supplier competitiveness in non-military settings, thus fulfilling the Dual Use philosophy that is so important in today's procurement environment.

Offshore companies that are utilizing more lean manufacturing concepts are seriously threatening many U.S. companies. For example, at the Management Briefing Seminar 2002[v], executives from the tool and die suppliers to the automakers were desperately discussing how to change their operations in order to compete with offshore tool and die companies. However, time is not on their side. If something is not done, then these U.S. and Canadian shops will go the way of the VCR industry. This may seem like an old story, but it is true and should not be dismissed lightly.

The next big U.S. industry being targeted by foreign competitors is the airframe industry. Because of this, the U.S. SME suppliers to this industry risk being severely reduced in numbers if something is not done now before offshore competitors develop "leaner and faster" operations. The emphasis is not simply labor costs, but also cycle time reductions. Furthermore, because of the heavy capital costs, long plant setup times and steep workforce learning curves, military planners cannot assume that this heavy tool industry can be quickly rebuilt once it is lost.

Because of the funding cuts to the program, the VAST program did not generate enough data to be statistically analyzed. But the VAST program results are consistent with other industry data in lean manufacturing technology applications, and the results from applying the STEPwise

methodology are also encouraging. These new technologies are becoming more important with the customers who recognize the need for more sophistication.

### 3.4.3 Customer issues

The airframe manufacturers including Lockheed Martin are developing more sophisticated supplier management strategies and this means that they are going to be more involved with their suppliers and demand more of them. These supply chain management tools and techniques will require that 2$^{nd}$ and 3$^{rd}$ tier suppliers be able to support the lean manufacturing techniques. These techniques, including just-in-time and the pull systems, will become more prevalent with their customers in both the private and military sectors of the airframe manufacturers. Consequently these lean customers will demand shorter lead times, production flexibility and lower costs. The VAST project addresses these demands and shows that the SMEs are capable of incorporating the needed changes.

### 3.4.4 Cost and Benefit Analysis

In order to show the power of lean techniques, the VAST team conducted a detailed analysis of specific manufacturing processes within the selected SME's manufacturing facilities. The 'as-is' manufacturing processes were captured and team members reviewed the data for accuracy. Once the baseline data was established, specific kaizen (improvement) events were performed to help the supplier improve on specific selected areas within the process. This data was captured and segregated into 'before' and 'after' scenarios in order to document the savings from the lean event. The raw data is in appendix A and summarized in the following cost benefits section.

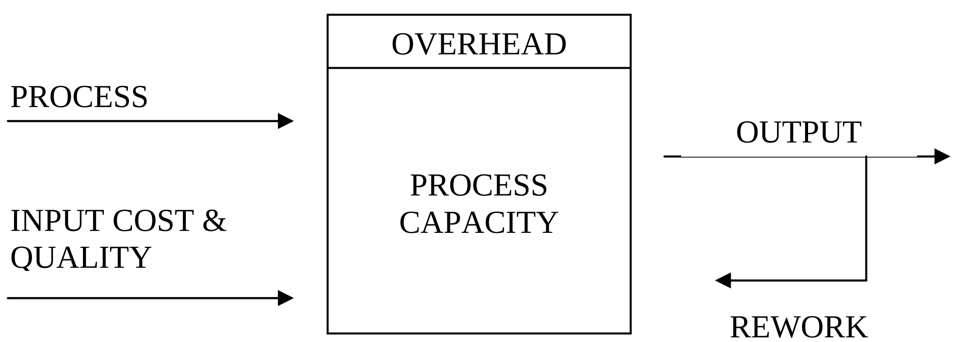



**Figure 15. Components of Operational Savings in Manufacturing Systems Processes**

The VAST team worked with the selected 2$^{nd}$ tier supplier to demonstrate the benefits of using lean concepts for reducing lead times and costs. Figure 15 shows the operation components that commonly provide savings when lean techniques and methods are applied. The principal benefits that result in operational savings are

- Reduced process load (less work coming into the process either new or rework)
- Improved input quality and reduced input costs.
- Increased process capacity

- Reduced process overhead, and
- Reduced defects (improved product quality and reduced rework)

### 3.4.5 Process Load

*Process load* is the amount of work in a process that requires human intervention. This load includes setup times, quality inspection, and information processing. However, these loads also include unnecessary work. For example, in processing product information, the reduction of paper processing is a reduction of process load. The lean concepts of value stream analysis, setup time reduction, mistake proofing (pokayoke) and autonomation (jidoka) also reduce process load. The results of the VAST project demonstrate how the lean and STEPwise methodologies will reduce process loads for suppliers.

The VAST team performed lean kaizen events at the supplier site for setup processes used to manufacture the F/A-22 lower beam. The results analysis identified reduced setup time from 156 minutes to 50 minutes or a 68% reduction on a single setup operation. The team identified 69 additional operations in the F/A-22 lower beam production run that would benefit from a similar setup reduction activity. Reduction times of 50-85% are the norm in these industries.

Table 2 below shows the process load reductions that occurred after the VAST team conducted kaizen events in the factory. The setup reductions were within the range expected by the team. This cycle-time reduction means improved customer service and reduced waste.

**Table 2. Expected vs Actual Results from Lean Activities**

| Process Loads | Expected | VAST Actual |
|---|---|---|
| Setup cycle time reductions | 50-85% | 68% |

### 3.4.6 Input Quality and Cost

*Input quality* is the quality level of materials and information received from suppliers. Although the VAST program did not assess any process improvements in the input quality and cost areas, Lean methods are known to produce improved outgoing quality. Creating supplier management programs and certifying incoming components will enable lower tier suppliers to improve input quality and costs. Creating vendor partnerships will streamline operations between customer processes and supplier processes. Consolidating purchasing with the F/A-22 program will allow suppliers to capitalize on bulk purchase agreements and reduce their materials costs.

### 3.4.7 Process Capacity

*Process capacity* represents the amount of work a process can handle with a given set of resources. Lean improvements in process capacity will allow 2$^{nd}$ and 3$^{rd}$ tier suppliers to increase their work volume without hiring more people or handle existing work loads with fewer resources. The VAST supplier reported that during the course of the program one of their machinists who was scheduled to work on the F/A-22 lower beam production run left their employ. They specifically noted that as a result of the application of the Lean concepts learned from VAST that they were able to complete the work without having to hire a replacement. The VAST “lean supplier” case demonstrates significant per unit cost avoidance. The lean events

conducted by the VAST team show both reduced cycle times and the elimination of non-value added work on the shop floor. This substantially increases a supplier's process capacity.

### 3.4.8 Process Overhead

Because process overhead was not a quantified item in the VAST program, actual overhead reductions are not part of this final report. However, in generally accepted accounting practices, reductions in direct labor will reduce process overhead. Furthermore, the lean concepts of standardized work and kaizen events also reduce the need for direct labor supervision. The case literature on lean methods indicates that a shop can expect to reduce its floor space needs by as much as 50%[vi] further reducing overhead costs.

### 3.4.9 Financial Assessment

In order to develop a financial assessment, a set of baseline metrics were established as follows:

- F/A-22 current projected annual build rate:
    - Total F/A-22s to be built = 331 aircraft
    - Production run = 12 years
    - Average aircraft per year = 27
- SME current production run:
    - Six lower beams per F/A-22 x typical production run of 2 aircraft = 12 lower beams per SME production run
    - F/A-22 build rate = 27 F/A-22s per year
    - Total number of F/A-22 production runs for SME = 13.5 per year

Based upon our supplier lean engagement event a business case was developed by extrapolating the labor cost and cycle time avoidance for the single part and process analyzed through a single F/A-22 lower beam production run, to an annual production set, and then to the total expected F/A-22 production of 331 aircraft over a twelve year period.

Significant reductions were noted as a result of these efforts. When one considers that the results reported below only address a single aircraft part and that the selected SME reported that over 95% of their business base is comprised of DoD parts provided to a number of weapon systems, the potential for savings becomes even greater.

- SME Setup Reduction Event for single production run:
    - As-is or current state setup time for selected machining process was 2.6 hours (156 minutes)
    - Following Lean implementation setup time was reduced to 50 minutes
    - The VAST team identified 69 other machining operations in the F/A-22 lower beam production run which use similar setup procedures
    - Total (extrapolated) setup labor per production run = 56 hours
    - Current state applied labor expenditures per production run = $3,643
    - Following Lean implementation setup applied labor expenditures per production run = $1,166
- **Projected Cost Avoidance from Lean Setup = 68% reductions in Cycle Time and Direct Labor**

- SME Setup Reduction savings for annual production of F/A-22 lower beam:
  - Annual Current State Setup Cost:
    - Production run x Applied setup labor per run
    - 13.5 x $ 3,643 = $ 49,181
  - Following Lean implementation Process Setup Cost:
    - Production run x Applied setup labor per run
    - 13.5 x $ 1,166 = $ 15,741
- **Annual Projected Cost Avoidance from Lean Setup = $33,440**

- SME Setup Reduction savings for 12 year production of F/A-22 lower beam:
  - Recurring annual cost avoidance $ 33,400
  - Setup time reduction = 68%
  - Cost avoidance over 12 year F/A-22 production run:
  - $ 33,440 x 12 years = $ 401,280

Based upon our supplier lean engagement event, the VAST team estimated that the initial investment attributable to the SME to implement the lean event was $17,500. Based on the metrics collected, the lean event showed a payback of 5 months.

Even with a payback of 5 months, this is still a significant out-of-pocket investment for a typical 2nd and 3rd tier SME supplier. However, because of the lessons learned on this F/A-22 part, the supplier was so encouraged by the lean engagement results that they independently conducted a kaizen event on a non-F/A-22 part for another DoD customer and realized reductions. Although these results were not captured as part of the VAST program, this shows what an SME can and will do once the benefits of lean manufacturing methods are understood.

### 3.4.10 Extending these Results to the Lockheed Martin SME Supplier Base

Sixty three SMEs were identified by the VAST team as suppliers to Lockheed Martin and the F/A-22 program that are currently known who are comparable to the supplier selected for the VAST lean event. These additional suppliers typically provide parts to five fighter aircraft produced by Lockheed. Table 3 shows how the VAST lean event rolls up to all these 63 SMEs. These roll up calculations assume that similar parts in this supplier set will produce similar savings. Further, we assume that the all five fighter programs will yield similar savings from a similar SME lean engagement. Because these VAST supplier lean engagement results are consistent with similar cases documented in the literature on lean manufacturing[vii], these assumptions have been made and provided.

**Table 3. F/A-22 Lean Engagement Cost Avoidance Rollup**

| VAST F/A-22 Project SME Lean Event Rollup | |
|---|---|
| Cost avoidance/F/A-22 supplier/yr | $33,440.00 |
| Number of Suppliers | 63 |
| Total F/A-22 Cost Avoidance/yr | $2,106,720.00 |

Table 4 shows the potential for cost avoidance across all five fighter programs. The estimated savings for all five Air Force fighter programs is in excess of $10 million.

**Table 4. Total Fighter Program Rollup**

| VAST Project SME Lean Event Rollup | |
|---|---|
| Cost avoidance/F/A-22/yr | $2,106,720.00 |
| Number of Fighter Programs | 5 |
| Total Fighter Cost Avoidance/yr | $10,533,600.00 |

The part studied in this VAST project is one of hundreds of machined parts in the aircraft supplied to the Air Force. Thus, these figures represent only a small portion of the savings potential for applying lean principles and practices in the SME supplier base. The potential savings are enormous and cannot be ignored. Lean is an important manufacturing paradigm that must be encouraged and supported in order to realize this significant level of program cost savings.

# 4 STEPwise Supplier Development Activities

## *4.1 STEPwise Background*

Evolving from the AF ManTech PAS-C Program, The STEPwise (STEP Web Integrated Supplier Exchange) project was originally conceived to enable supplier integrated product development by automating the exchange, review, and processing of electronic technical data packages (TDPs) in the supply chain. As shown in Figure 16 below, STEPwise represents a proactive effort to optimize information flow by providing the standards-based infrastructure necessary to achieve tangible benefits resulting from improvement in the technical problem solving and product flow value streams.

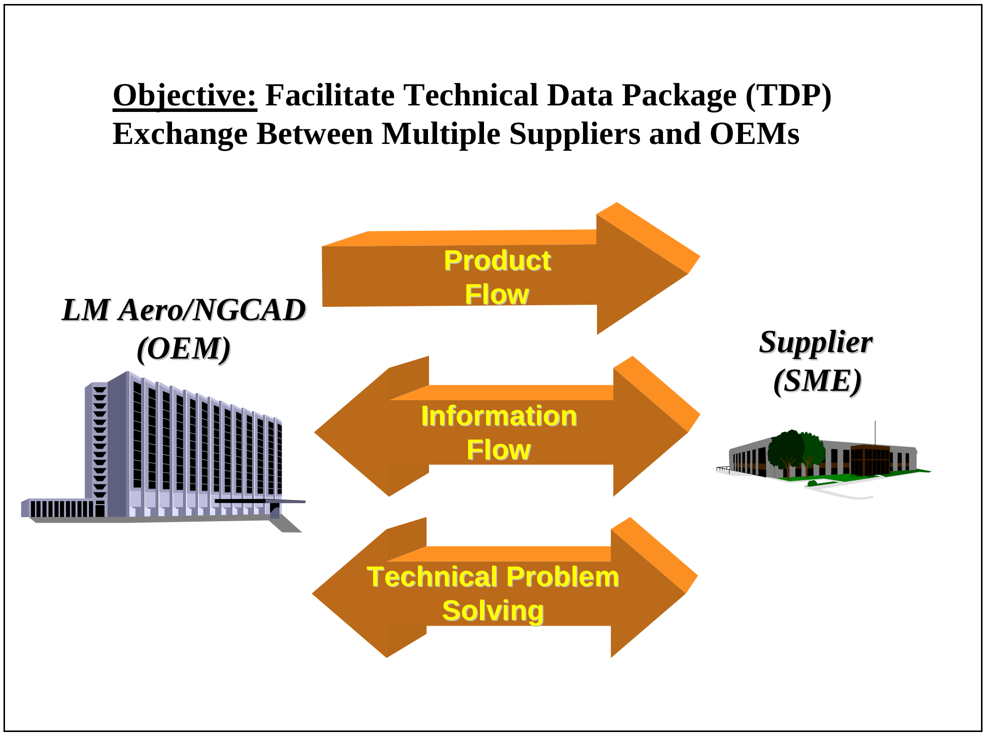



**Figure 16. STEPwise – Applying Lean Concepts to Information Flows**

From inception, this supplier development activity sought to develop a broadly usable solution that met the needs of both prime contractors and suppliers. One of the catalysts for STEPwise is the effective utilization of the ISO 10303 STEP family of standards to facilitate the data exchange process. By adopting a standardized approach, STEPwise provides suppliers the ability to efficiently meet the needs of all their customers according to their best business practices. Using STEPwise tools, suppliers can exchange and manage the technical data they receive from all of their customers in a single system. It is intended for broad scale deployment and is simple, scalable, and affordable. Personnel requirements, technology infrastructure, and overall cost are within the reach of even the smallest suppliers.

In addition to validating the technical approach, the VAST team developed a business case for automated TDP exchange.  The STEPwise business case represents an accumulation of input from prime contractor (Lockheed Martin Aeronautics Company) and a representative supplier which includes man hour estimates for specific technical data processing tasks, average man hour costs, and projections for future technical data exchange requirements.  The STEPwise business case is explained in more detail later in this document.

The first step in exchanging a technical data package (TDP) as shown in Figure 17 is for the originator to create the TDP.  At LM Aero, this process is started when the Procurement Department generates a list of data items that need to be sent to a particular supplier in support of, for example, a Request For Quote (RFQ).  This list is then sent to the LM Aero Data Transfer Group.

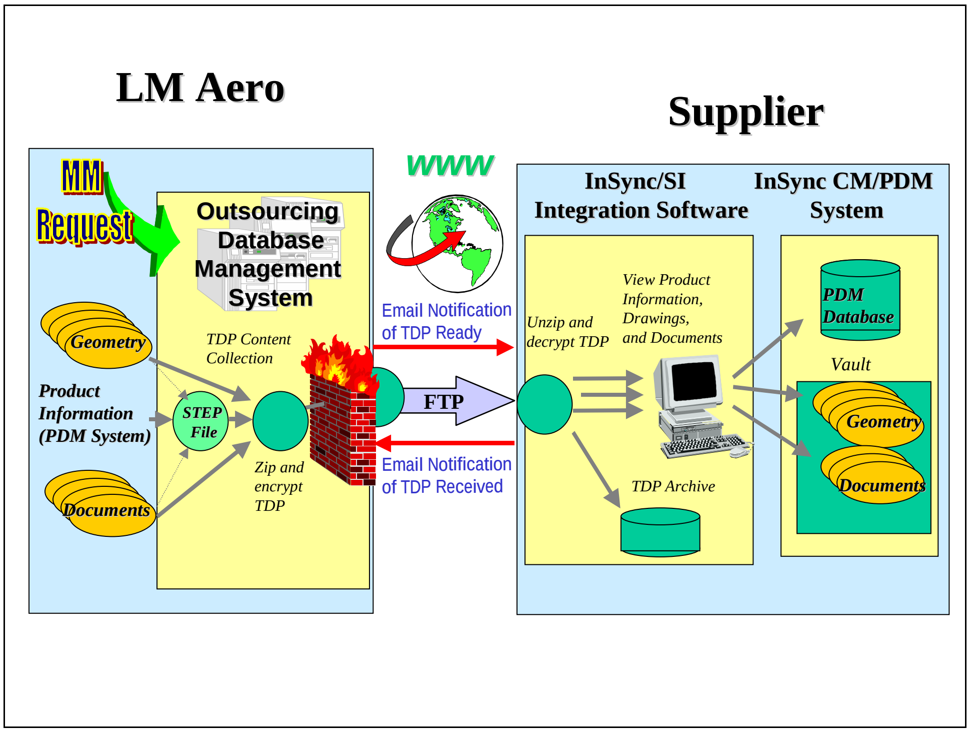



**Figure 17.  VAST STEPwise Implementation**

The Outsourcing Database Management System (ODMS), which was developed by LM Aero to facilitate technical data package exchange, processes the request by pulling the data from the appropriate sources.  The data pulled into the TDP may include drawings, various documents such as specifications, and of course, product meta-data from product information systems. A STEP file is generated which represents the applicable product information, the files contained in the package, and the relationships between the product information and the files.

Once the STEP file is generated, the TDP files are collected, compressed (using a standard zip utility), encrypted (using PGP), and placed outside the firewall on a supplier accessible FTP site.

ODMS then generates a notification, which includes an embedded FTP link to the TDP file, and e-mails the notification to the subcontractor to inform them that their data is ready for pick-up.

When the supplier receives the notification, they simply click the embedded FTP link to start the download process. The TDP download initiates the STEPwise integration software, which automatically decrypts, decompresses, and archives the contents of the TDP. The information represented in the standard TDP file is converted to HTML so that it can be displayed within a web browser, and the local web browser is invoked for TDP review.

Once the supplier completes the initial TDP review, they simply click a button and the product meta-data contained in the STEP file is automatically loaded into the suppliers local Product Data Management/Configuration Management (PDM/CM) system, the files included in the TDP are vaulted, and a workflow is generated to initiate the supplier's formal, internal procedure for processing the bid package.

### 4.1.1 Technical Data – Paper versus Digital

STEPwise offers a strong approach to supply chain integration and provides the framework necessary to enable suppliers to efficiently process the vast amounts of technical data that will need to be exchanged and managed in tomorrow's manufacturing environment. Historically, data for legacy systems resided only in manual formats (e.g. hand drawings or vellums).

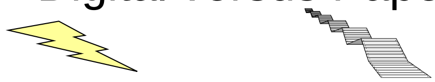
Even though technical data is available in a digital format, SME's are not all able to, or are not all motivated to receive digital data and LM Areo procurement buyers would print out paper copies from the various systems and then distribute those to the supplier by postal mail or courier. This activity typically would occur when engaging a Build-to-Package (BTP) supplier for a Request For Quote (RFQ) or after the award of a build contract or Purchase Order (PO). A goal of the VAST program is to provide the validated business case necessary to motivate SME's to develop and implement capabilities to take advantage of receiving and handling the TDP via digital formats.

STEPwise uses a combination of ISO and Industry standards formats within its TDPs. The Defense Logistics Agency (DLA) has mandatory standards for various data types. The formats used in the LM digital TDPs also follow closely these mandatory DLA standards and typically comprised of TIFF, MS WORD, TEXT, Native CAD, IGES, STEP, and PDF formats.

Configuration Management (CM) data is the ringmaster of the TDP. It tells how all the data within the TDP fits together and how it fits with other product data the SME may already have in their data management system. Prior to STEPwise, the CM data was printed out from the Multi-Program Release System (MPRS) and sent it along with the other pieces of the RFQ or PO. With STEPwise, the CM data is extracted from MPRS in a STEP format. Since CM is the ringmaster of the TDP, the receiving SME data management system will be able to process the various pieces of the TDP based on what the CM data says about the various pieces.

Figure 18 below shows a comparison of information exchange between a paper and digital environment.

Information Exchange:
Digital versus Paper



| | |
|---|---|
| Immediate availability | Delays of days or even months |
| Product/Change info loaded automatically | Manual re-keying, verification, and notification |
| Reduced flow time for changes | Manual notification, acceptance, review, approval, ,... |
| Increased accountability | Manual procedures to prove compliance with ISO, LEAN, … |
| Reduced costs | People costs, Paper costs, Re-work Costs, Opportunity costs, … |

**Figure 18. Information Exchange: Digital versus Paper**

Some key points to consider when utilizing a digital distribution of technical data to suppliers versus paper include:

- Manual re-keying is error prone and can take multiple iterations to properly enter product data into a supplier's internal systems.
- Even worse, supplier could be forced to rely on paper to drive internal processes.
- Digital data management enables process automation, which reducing errors, improves communication, and provides the supplier and their customers with an efficient means comply and prove compliance with applicable requirements.
- Digital data reduces costly man-hours, eliminates costs associated with physically managing paper (material, delivery, storage), reduces errors and therefore re-work, and finally increases opportunities.
- In general, adopting a digital data exchange strategy should positively impact the following areas:
    - Distribution, Reproduction(s), Physical size/oversize problems
    - Inaccuracies, Inaccessibility, Redundancy
    - Validation/Verification, Reconciliation
    - Monitoring and Tracking, Physical Libraries/Cribs
    - Reporting, data collecting

### 4.1.2 What's in a TDP?

On the F/A-22 program LM Aero pulls together technical data from various LM data repositories and systems that collectively encompass a product definition. This collection is referred to as a Build-to-Package or Technical Data Package. Components of a typical TDP include drawings,

parts lists, Planning Outsource Instruction Sheets (POIS), CAD parts and cutting specifications, process standards, and any outstanding Engineering Change Notices (ECN) not incorporated into a release controlled product definition.

On a large Request For Proposal (RFP) may address numerous part numbers with several suppliers getting varying combinations of these particular part numbers. Thus, creating a paper TDP is very labor and material intensive as well as being quite inefficient. A subsequent sorting and filing effort would typically follow at the supplier's site, propagating the waste and unnecessarily increasing the cycle time.

STEPwise supports the distribution of this data in a digital form and has introduced a packaging method that will organize the data in logical TDP's. Several utility programs have been developed and are in place to support the extraction of the TDP elements in various formats. These elements are then packaged and distributed in a computer interpretable "shipping list" via the use of the ISO 10303 Application Protocol 232. This format will allow industry and the supply chain to migrate from the classic methods of data management to the newer methods of managing the product data via data management systems.

The distribution of STEPwise generated TDPs utilizes web-based technologies. The concept behind a web-based technical data package is that the data should be available online through an affordable, secure interface leveraging Internet based technology. Extending the current capabilities of the web-based software for AP 232, low cost access to technical data package information could be made available independent of where the individual elements were located. This would provide for a broad based distributed storage approach that would enable small manufacturing companies to have access electronically to the data they needed.

### 4.1.3 Previous LM Approaches to STEPwise Supplier Development

LM Aero has evolved their engineering processes from a paper-based system to one that relies on sophisticated information systems technologies. This includes CAD/CAM, Product Data Management (PDM)/Configuration Management (CM), planning systems, and document repositories. While the engineering environment has made this progression, the business processes have lagged behind which includes the procurement arena. Recently, the procurement area has become the larger focus as LM Aero relies more heavily on outsource suppliers to manufacture components and assemblies from LM Aero provided TDP's.

## 4.1.3.1 Unstructured digital files to Structured TDPs

The first progression that LM Aero has made to a paperless distribution of digital data is the dissemination of technical data to suppliers. Initial activities focused on locating the data, extracting the data from it data repositories and converting it to non-proprietary formats. Depending on the supplier, there were differing format selections for the conversion process. The data components were then sent to the supplier via disks, tapes, and CD-ROM's. Upon receipt, the supplier would have a series of files in a myriad of formats. Unfortunately though, the naming convention of the files coupled with the magnitude of data distributed laid a heavy burden on the supplier to determine the content of the distributions. Figure 19 provides an example of unorganized digital files. Clearly, simply sending digital data without a means of organization is not sufficient and often compounded the problem.

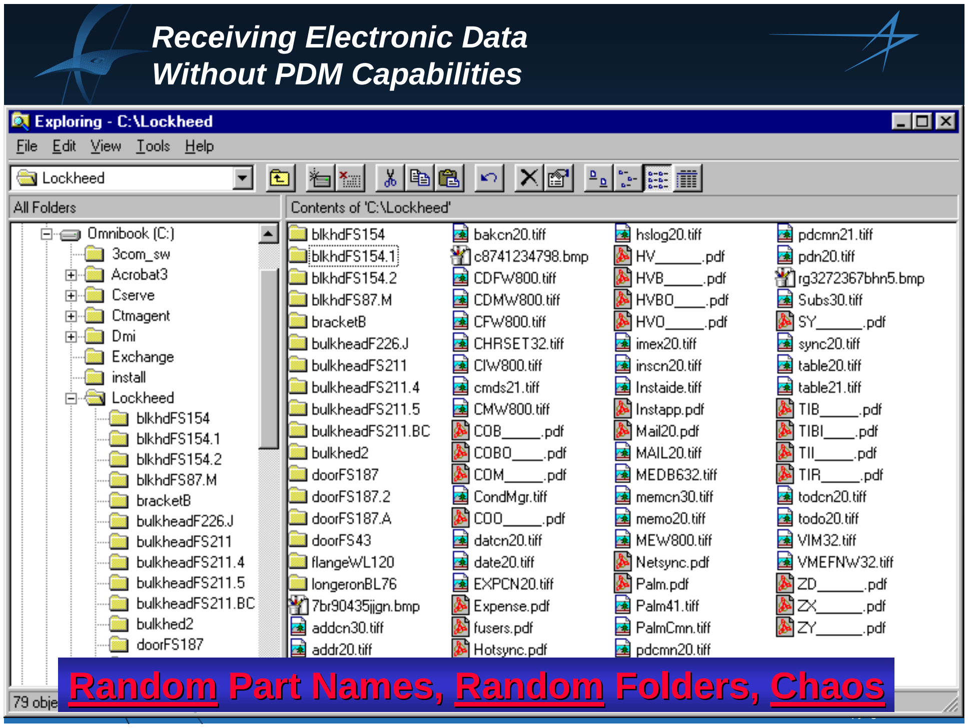



**Figure 19: Unstructured Digital Files**

The issue was how to distribute the digital information with some intelligence to the package including associations of physical files to an engineering product structure. The capabilities of the ISO 10303-232 Application Protocol that was adopted by the VAST team provided a solution to this dilemma and offered an ISO standard based solution to the F/A-22 program and its supply chain.

## *4.2 STEPwise Concepts in Industry Today*

To reduce the time to market, Original Equipment Manufacturers (OEM's) are outsourcing more and more tasks to suppliers. OEM's are experiencing a need to partially outsource the manufacturing of new products to decrease manufacturing costs. The ability to quickly and efficiently exchange design information will accommodate this increasing industrial need. Outsourcing production bring rise to the need for more efficient, problem-free methods of exchanging information as does data sharing among all members of an Integrated Product Team (IPT), regardless of their physical locations. To improve communications between separated business units, component manufacturers, component suppliers, and OEM's, the Internet is being used to distribute digital definition data. To support this growing need, industry must adopt a uniform set of common standards. Common standards will provide industry with a means to directly integrate component information with their internal software tools used for computer-aided design and computer-aided-manufacturing.

A recent study by the Research Triangle Institute estimated that the inability to electronically communicate product data across different production activities imposed a $1 billion per year cost on the U.S. automotive supply chain ("Interoperability Cost Analysis of the U.S. Supply

Chain Pilot" available on the web at http://www.rti.org/pubs/7007-3-auto.pdf). By far, the greatest component of these costs is the resources devoted to repairing or reentering data files that are not usable for downstream applications.

In addition, the DARPA-sponsored STAMP program (http://www.spans.org/projects/stamp/) led by ATI is piloting the specification with the Raytheon missile supply chain. These efforts promote a solution that will allow a supplier to exchange and manage technical data from multiple customers using a single system.

### 4.2.1 VAST STEPwise Team

The participants for the STEPwise activities on the VAST program comprised of representatives from ATI, LM Aero, selected LM Aero suppliers, ISS and Theorem Solutions. The supplier selection process on the STEPwise portion of the VAST program entailed a review of SME's fitting the profile that they were active F/A-22 subcontractors and were receiving TDP's from LM Aero on a consistent basis. LM Aero buyers were queried for a viable list of candidate SME's and a selection was made based on the defined criteria from this list.

### 4.2.2 VAST STEPwise Supplier Profile

The selected STEPwise supplier is a metal fabrication company. Some of their capabilities include:

- Forming – can perform most hydro, brake, draw, and roll forming operations
- Shearing & Punching – close tolerance punching operations
- Machining – profiling, turning, CNC milling, and wire-cut
- Assemblies – certified spot welding, rivet squeezing and shaving, and other types of high production fastener installation
- Processing – application of alodines, epoxy primers, and urethanes
- Outside Production – excellent supplier list to perform chem-milling, heat-treating, laser cutting, or non-destructive testing.
- Quality Control – quality system meets Mil-1-45208.

Some newer capabilities this supplier now has includes:

- Solution treating
- Straightening
- Aging
- Punching & nibbling
- Skin forming
- Draw forming

The supplier makes approximately 1400 different part numbers a year for LM Aero that comprises approximately 60% of their business base. This supplier also handles approximately 3 times this number of RFQ's (different part numbers) on an annual basis. This supplier actively does work for LM Aero programs such as F/A-22, F-16, and C-130. They are also a supplier for Vought Aircraft Industries, the Boeing Company, and Northrop Grumman performing work in both the defense and commercial aircraft industries.

As a result of previous activities with LM Aero and the migration towards the use of digital data, the STEPwise supplier on the VAST program had some exposure to the handling of digital data.

However, the use of the suite of VAST provided tools including the InSync PDM system was completely new to them.

## 4.3 Goals of the STEPwise Supplier Development Activities

A part of the VAST Program was to apply lean concepts to the exchange, review, and processing of electronic technical data packages (TDPs) in the supply chain. This represents a proactive effort to optimize the information flow value stream, providing the standards-based infrastructure necessary to achieve the tangible benefits resulting from improvement in the technical problem solving and product flow value streams.

The VAST team adopted an approach from LM Aero's Lean Manufacturing team philosophy by using a Value Stream Mapping (VSM) event to capture the activities, span times, labor, wait states, movement stages, waste areas, etc., within the RFQ and PO processes. This comprehensive mapping event produced a flow chart of each process, detailing activities in the current ("as-is") process with paper TDP's, as well as the future ("to-be") process utilizing an automated approach.

One of the key objectives of the VAST program was to address current processes, involving TDP handling at LM Aero and their SME's, and potential improvements to those processes. The VAST team focused on two of the SME's paper-based processes involving TDP handling. The first was the Request for Quote (RFQ) process and the second focused on their Post-Purchase Order (PO) activity that deals with contract review and planning.

Once the tools were in place at the SME's facility, manual and automated TDP's were prepared by LM Aero and provided for processing. The SME processed the TDP's in both the current and future process flows, documenting the process times with both flows for later evaluation on the business case.

## 4.4 STEPwise Benefits to Suppliers

Benefits to STEPwise SME suppliers include quality improvements, timeliness of data availability, access to a common data repository, and overall increased productivity and competitiveness. Additional expected benefits are summarized in Figure 20 below.

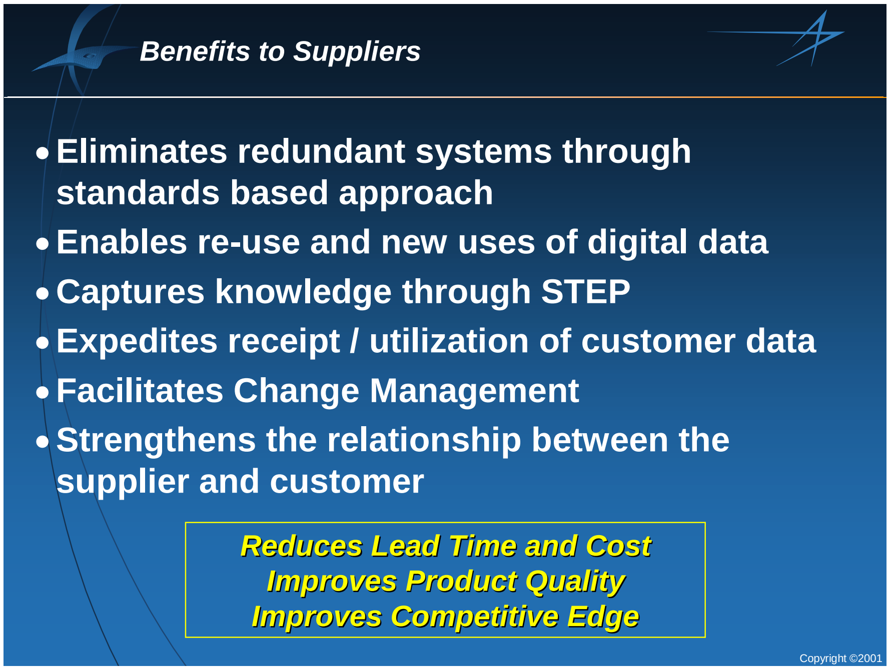



**Figure 20: STEPwise Benefits to Suppliers**

The VAST team recognized several benefits that would be seen through the expanded implementation of the STEPwise process in the supply chain. First, the suppliers becoming more competitive and efficient in their handling of digital data versus paper packages would be able to respond to RFQ's and PO contracts more expediently. This produces a better quality and priced product in a reduced timeframe back to customers. In return, the supplier will have the capability of accomplishing more work with reduced manpower levels through the use of this newer technological approach.

LM Aero and other DoD primes typically recognize suppliers who continually perform at a high level through several programs such as the LM STAR Supplier program. Suppliers who qualify for these award programs are put in a higher visibility status that will provide the supplier a good opportunity to receive more work due to their exemplary work history and their ability to keep pace with technology.

Successful suppliers do 5 things, in particular, better than their competitors. They are: (1) better at reducing manufacturing complexity; (2) more aggressive in adopting state-of-the-art technology; (3) more aggressive in reducing material costs; (4) better at lowering operating costs; (5) better at focusing research and development. Attaining those skills are key elements in becoming true partners that are not easily discarded during industry downturns.

### 4.4.1 Quality Improvement and Timeliness of Data Availability

For quite some time, one of the largest negative factors on the timeliness for a supplier to respond to a RFQ and to produce and deliver a product to LM Aero has been incomplete Build – to-packages. This problem has existed in both the paper distribution environment as well as the

unstructured digital world. As seen in the process maps produced in the VSM events, the wait times for requesting additional data and the lag until that information is received is one of the most significant waste areas in both the RFQ and PO processes.

The VAST STEPwise process has provided a solution to intelligently pull product definition data based on a given part number. By accessing the PDM data relative to a part or assembly, the software can extract additional related digital data not intuitively requested by the buyer. By adding some of the requested enhancements from the supplier, this TDP has closed the gap on this issue. LM Aero has taken initiative to apply the proper internal procedures in place to assure complete TDP's are distributed to their suppliers.

### 4.4.2 Common Data Repository

Another issue that has been a problem in the world of paper drawings has been the requirement to make multiple copies for viewing by more than one person at a given time. This process leads to the potential of differing versions existing at the same time with different personnel. With the widespread acceptance and implementation of ISO 9001 standards in industry, this process is no longer a viable method.

The STEPwise approach provides a digital solution to this problem. By having a common repository of digital data and through the use of a software solution such as InSync to retrieve this data from the repository, multiple users can simultaneously access files assuring that the current version is in the repository. This eliminates the quality issues (rework and scrap) that can occur by using old data common in a paper environment.

Another benefit to storing the digital files in a common repository is there exists a master copy of the data being distributed from LM Aero to their suppliers. The STEPwise approach to digital data distribution also reduces manpower requirements at the supplier's facility related to the management and inventory of this data (paper versus digital).

The STEPwise approach utilizes InSync, a PDM/CM implementation, as an integral part of the process. The following is a list of what a PDM/CM implementation could provide to a supplier:

- Find, access and share information in a distributed environment
- Facilitate concurrent or simultaneous engineering practices
- Enforce conformance to, and use of, standard operating procedures
- Support for regulatory compliance or certification (e.g., ISO 9000)
- Facilitates the transition from manual paper-based processes to implementing automated electronic-based processes
- Integration of engineering, manufacturing, and business systems
- Improve metric reporting of business processes
- Shorten time-to-market, decrease development time

### 4.4.3 Increased Productivity and Competitiveness

Through the use of the STEPwise process and information systems such as InSync that provides capabilities such as PDM and Configuration Management (CM), the supplier becomes more sophisticated in their business. This sophistication allows for a higher level of productivity and increases their competitiveness.

As the supplier base becomes more sophisticated in their method of handling data from their customers, the opportunity exists to expand this technological capability to other programs the supplier participate in. Other prime contractors, like LM Aero, are in the process of implementing common digital data distribution solutions based on the STEP standard. Once a supplier is trained and has demonstrated the capability to thrive in a digital environment, the benefits of the STEPwise process will extend to other defense programs. Some other OEMs and organizations that are working towards a common solution include:

- Northrop Grumman - participated in the STEPwise pilot and was acted as the leader in the development of AP232
- Boeing - has a significant undertaking related to the use of AP232 with their Define and Control Aircraft Configuration/Manufacturing Resource Management (DCAC/MRM) program.
- Other organizations such as BAE Systems & the French Space Agency (CNES) have identified a need for an AP232 implementation in their business processes. They are active in the development and deployment efforts of a system that utilizes AP232 as a basis for the packaging and distribution of digital data.

The development of a proper business case is critical to the success of any major technological development project. In addition to the realized benefits of the STEPwise process internal to LM Aero, significant benefits were expected at the supplier's end of the process. During an earlier initial phase of the STEPwise pilot, savings to the suppliers that implemented this process, utilizing InSync software, was projected. This projection shown in Figure 21 was estimated at $64,000 per supplier per year.

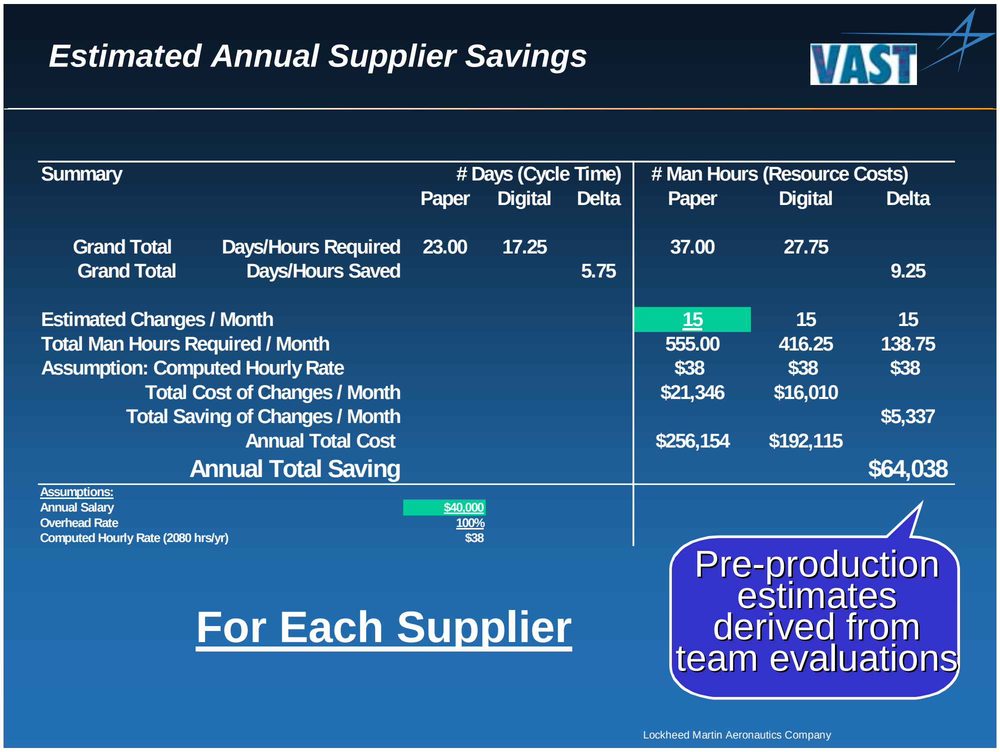



**Figure 21: Estimated Annual Supplier Savings**

## 4.5 VAST Approach to STEPwise Supplier Development

As the DoD prime contractor for the F/A-22 program LM Aero has several requirements and initiatives the VAST program attempts to address. First, LM Aero is migrating to a digital distribution of TDPs to their suppliers. Also, LM Aero has several initiatives to consolidate their supplier base while assuring this base is adequate to fulfill contract requirements. This becomes more of a challenge as more BTP work is offloaded to outside vendors, many of which are SME's. As a result, the requirements at the SME become more critical to the success of fulfilling contract needs of which, LM Aero is quite sensitive to.

As a result, one of the objectives of the VAST program is to address current processes, involving TDP handling at LM Aero and their F/A-22 suppliers, and potential improvements to those processes that STEPwise can provide. The VAST team focused on two of the SME's paper-based processes involving TDP handling. The first was the Request for Quote (RFQ) process and the second focused on their Post-Purchase Order (PO) activity that deals with contract review and planning.

Once the VAST SME was selected, representatives from the SME were provided training on the tools that were provided as part of the STEPwise toolkit on the VAST program. Following the tool training efforts, an overview of the overall STEPwise process was provided as a lead-in to the efforts for documenting the current and future flow for the targeted processes.

Once the tools were in place at the SME's facility, traditional and STEPwise TDP's were prepared by LM Aero and provided for processing. The SME processed the TDP's in both the

current and future process flows, documenting the process times with both flows for later evaluation on the business case.

### 4.5.1 Value Stream Mapping & Kaizen Events

The team met at the supplier's facility on several occasions in order to apply the Lean Manufacturing model of identifying current and future processes and to produce a Value Stream Map (VSM) of these processes. The initial session included an overview of the VAST program and the desired objectives from not only the program but the VSM's as well. The supplier captured the data for the current ("as-is") process for later analysis. An intensive analysis was conducted, led by a Lean facilitator, to capture all the steps, movement of information, and wait states. Waste areas were highlighted for opportunities to optimize the process. For instance, there were several 'information loops' seen in the paper process where missing or inaccurate data resulted in significant delays waiting for correct information. These areas were focal points as the team produced the process maps for the digital approach to the processes.

Follow up Kaizen events were conducted at the supplier's facility to answer questions, clarify process steps and apply span times and labor estimates to each step in the flow. These events also gave an opportunity for the team to assure the accuracy of the data captured addressing the process flows. During the Kaizen events, a metrics capturing session was also conducted as a TDP was "walked" through the exchange process using the STEPwise approach and raw data was documented for the business case portion of VAST.

During each of the events, team members interacted to identify areas of improvement within the business process that were not identified as primary objectives of the VAST program. Several suggestions were received from the supplier to LM Aero and were taken back for corrective actions to further enhance the supplier's ability to respond to RFQ's and to perform to contract.

### 4.5.2 Request For Quote (RFP) & Purchase Order (PO) Process

The RFQ process addresses a requirement for LM Aero to receive price quotes on efforts to produce parts conforming to a provided Build-To-Package (BTP) or Technical Data Package (TDP). A LM Aero buyer will prepare a spreadsheet summarizing the parts and estimated quantity to be bid. All pertinent information must be submitted to the supplier in order to get an accurate quote returned to the buyer. The package is sent to the supplier via US Postal or courier service. This quote typically includes a spreadsheet and a Microsoft Word form that is provided to the supplier for data population. Historically, the buyer has submitted drawings, parts lists, and LM Aero specifications in paper form to the supplier to fulfill the information package.

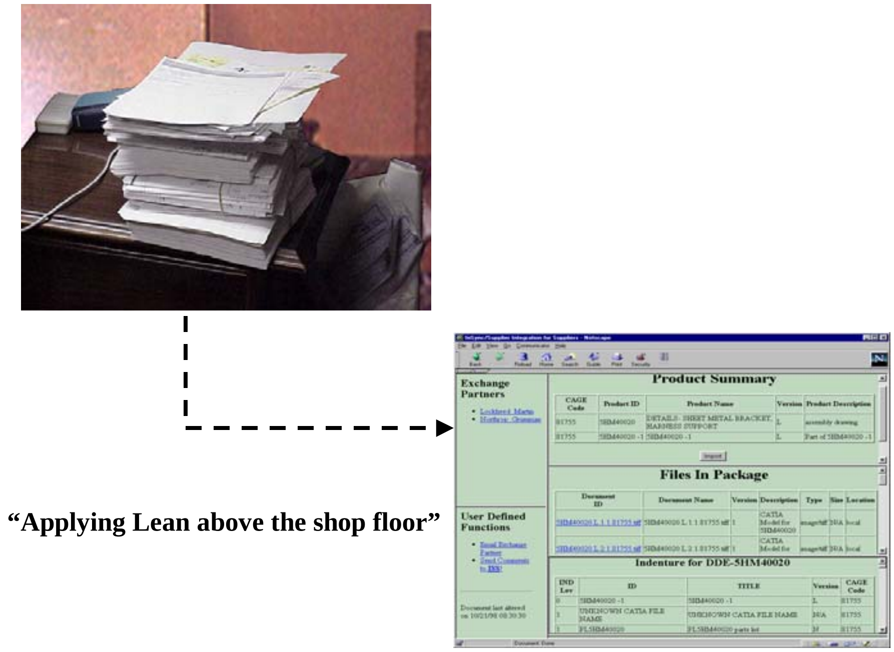



**Figure 22. Automating Technical Data Packaging Processes**

From the supplier’s perspective, the RFQ process typically involved a large bid package received from LM Aero leaving the supplier to wade though a large amount of data before actually quoting the particular job.

The normal process of reviewing a RFQ package would include:

- Receive package through mail/delivery system.
- Wait for drawings if necessary and, if not, pass package to estimator who reviews for adequate information and pulls the specifications.
- If outside processing is necessary to obtain, contact purchasing for availability of parts.
- Receive response from outside suppliers and submit to estimator.
- Estimator determines price and sends to contracts where a formal bid is submitted.
- Drawings are filed and the quote is entered into database.

Each RFQ received usually contained bid requests for approximately 30 parts. Also, while some parts were on drawings on hand, a large number required some drawing review.

The PO process occurs after a supplier has been awarded a contract to build a part or if a follow-on order is required to a supplier on contract to provide a certain part for a prescribed period of time. Usually, STEPwise supplier # 2 could expect to see a bid win ratio of approximately 30%.

The buyer will prepare the necessary purchase order paperwork in the appropriate system as well as any additional information required for the supplier to perform the manufacture of the part (this may be additional information not originally submitted in the RFQ or updated information available from the time the RFQ was exercised). This was also traditionally done in paper form unless the product definition required was resident in some CAD system. In these cases, special

requests were made of LM Aero Engineering departments to export the necessary CAD files for delivery to the supplier, usually via the postal service.

At the supplier's end, the normal process of reviewing a PO Process would include:

- Purchase order is received, sorted and reviewed to determine if it is a new purchase order or not. If it is new, a comparison takes place with the supplier's information on file. If data is different, customer is sent a fax for verification. If the PO is not new, the supplier will pull existing documents.
- A contract review takes place between the existing purchase order on file and the order coming in. If everything is in order, the PO will be entered into their system, if there are disputes they will be negotiated before order is entered.
- A PO file is then created, and inventory status is reviewed. The LM Aero Planning Outsource Instruction Sheet (POIS) level is also checked with what's on file. If different, the buyer at the supplier will request confirmation and wait for additional data. If the POIS level is the same, a job folder is created.
- In the job folder, data is entered and certifications are filled out. Once all data is reviewed a decision to convert to an order is confirmed and part is processed.
- Once the supplier is notified of the award, they have to manually look for the respective RFQ's in the filing system.
- A review then takes place to make sure they have the correct information (i.e., latest revision on drawings, quote/bid price and the same, date of delivery/date promised are also equal).
- Long delays could be realized if there is any missing data from the build-to-packages.

### 4.5.3 STEPwise Supplier Training

The VAST team conducted a two-day training session for VAST supplier. The training provided an overview of the STEPwise project, instruction on applicable InSync functionality, and an explanation of the setup requirements.

Following the training session for the STEPwise tools, separate Value Stream Mapping events were conducted. The VSM events identified the processes requiring the handling of TDP's to be addressed by the VAST program. LM Aero also provided an overview on their approach to making the handling of TDP's more efficient through the use of the STEPwise process and toolkit. This included discussion of what content to expect in a TDP. As this can vary from program to program, LM Aero also covered typical variances a supplier might experience when working on various LM Aero programs.

The training sessions held attempted to focus on applicable use of the tools and how this related to the philosophy LM Aero has adopted for the packaging and distribution of digital TDP's. Feedback was actively sought from the SME team members during the training as well as throughout the VAST program in order to identify improvement opportunities.

### 4.5.4 STEPwise Software Tools

The tools deployed by VAST to enable suppliers to efficiently process digital technical data packages included InSync, a full-featured, rapidly deployable PDM/CM system from Integrated Support Systems (ISS), and CADViewer, a CAD viewing tool from Theorem Solutions which is

noted for it’s support of STEP formats.  Early Value Stream Mapping events revealed that suppliers could realize significant savings through more efficient processing of the Formtek TIFF files included in the technical data packages.  As a result, the VAST team also facilitated the deployment of Imagenation, a viewing tool from Spicer Corporation that offers support for the Formtek TIFF format.

ISS's InSync software emphasizes an “off-the-shelf” philosophy that allows users to immediately obtain benefits in terms of cost reductions and enhanced quality.  InSync is available in a variety of scalable options making it appropriate for suppliers of all sizes.  Even small SMEs managing just a few parts will be able to utilize the capabilities of InSync to take advantage of reduced lead times, improved accountability and reduced man-hours that electronic data delivery provides. InSync streamlines product data management so it is organized and immediately accessible throughout the bidding and engineering change processes. As shown in Figure 23 below.

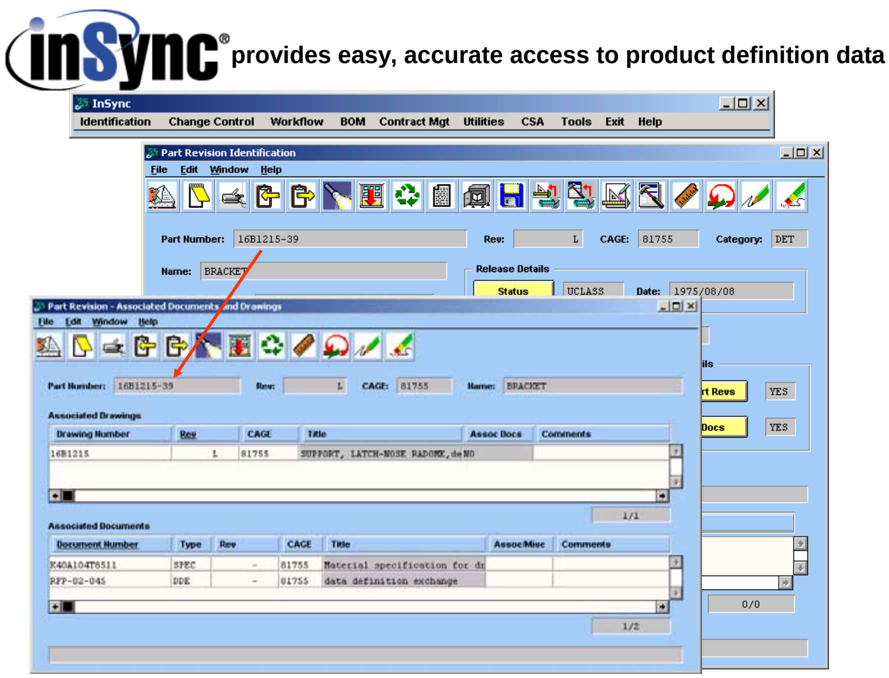



**Figure 23.   InSync Links to Critical Data Elements**

InSync can dramatically reduce the overall lead time and man hour requirements associated with obtaining data, distributing product information, estimating costs, and managing the bid or change process.  Medium to large companies will require the ability to control change data online, manage the change process, and distribute data throughout the organization.  InSync's workflow and change control capabilities can facilitate integration with the other activities in the organization to ensure changes are incorporated properly, completely, and in a timely manner. InSync also offers powerful integration capabilities that can be used to automate internal processes by facilitating the pull of product data information from or push to other enterprise systems in use by the supplier.

CADViewer is a powerful decision support tool for all aspects of Engineering Design and Manufacturing Data Exchange Engineers, Engineering Managers, Program Managers, Project

Engineers and Buyers. All disciplines who need to access engineering product definition data as part of their decision making process, will gain significant benefits from the use of this easy-to-use point-and-click tool. The CADViewer product provides the ability to view and interrogate, at a detailed level, original design definitions without the need for duplicate data models, or additional CAD software licenses, with their inherent complex operating procedures. An example of the CADViewer capability to read 3D models is shown in Figure 24.

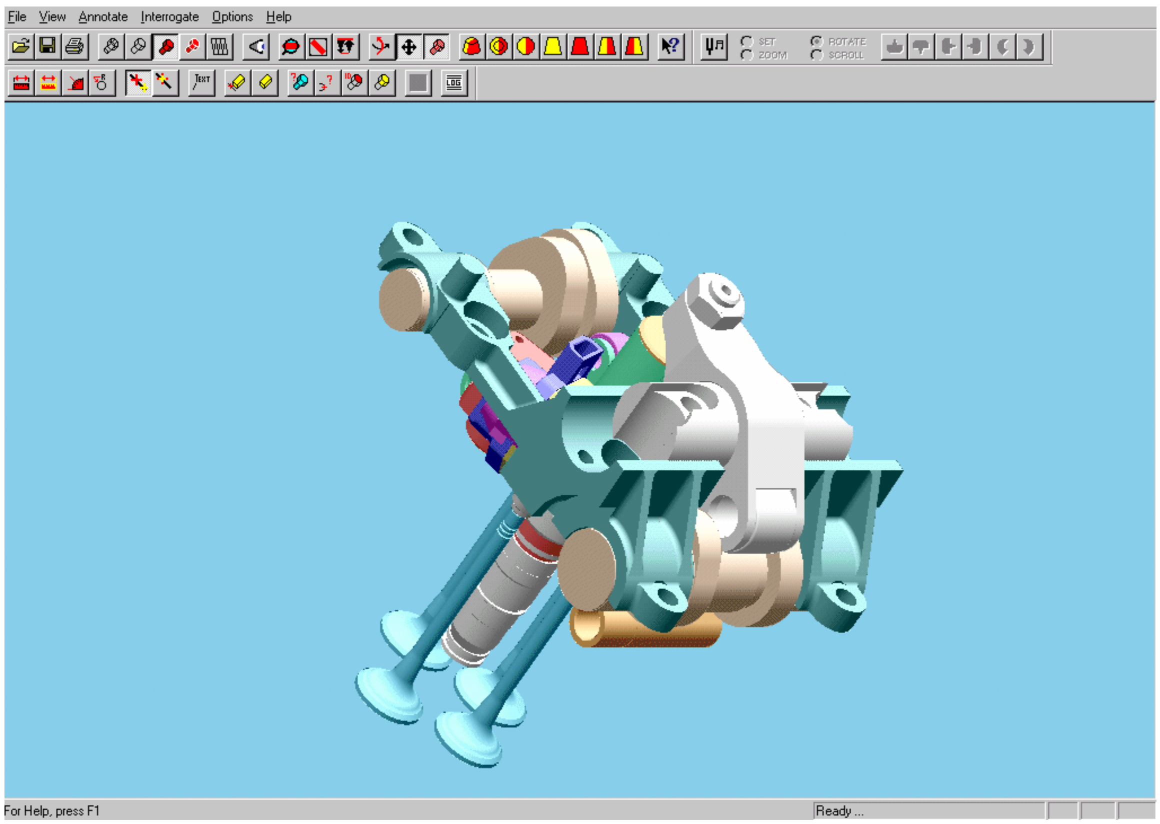



**Figure 24. CADViewer Import Capability**

### 4.5.5 STEPwise Digital Data Packages

The technical data packages used on the VAST program were selected from recent RFQ submittals for F/A-22 parts from LM Aero. The SME worked with the VAST team to capture labor and span time data by following the process maps laid out in the VSM events. The Labor and span times are used directly in the VAST business case.

In processing the TDPs for the PO process, a subset of parts was selected from the first RFQ package based on awarded contracts to the SME. LM Aero produced updated and improved STEPwise TDPs for these parts. The improvements to the STEPwise TDPs were the result of ongoing communications between the VAST team and the supplier.

## *4.6 VAST Supplier STEPwise Engagement Results*

Value Stream Mapping events were conducted at the STEPwise supplier site for both the RFQ and PO processes. VSM events allowed the team to develop the VAST business case using the

same methodology for both STEPwise and Lean suppliers.  VSM at the STEPwise supplier focused on the business processes targeted for improvements.  The primary areas of interest were receipt of data for a Request for Quote (RFQ) and the receipt of data at post-purchase order award.  The team mapped out the current process and focused on areas of waste and where the use of digital technical data packages could optimize the processes involved.

For the initial VSM event, no particular product was selected for the exercise, but rather the RFP and contract/planning processes were isolated for evaluation.  Initially it was believed the RFP process would realize the greatest savings by using the STEPwise distribution of digital data.  During discussions of the STEPwise process and supporting software solutions such as InSync, the team determined a majority of process improvement would be seen in the contract receipt and planning preparation process.  As a result, both processes were mapped.

A key waste-area was identified in the current process related to incomplete TDP's and waiting for data from LM Aero as an inhibitor to schedule performance.  The proposed migration to the STEPwise processes corrected this as the software suite allowed LM Aero to validate the completeness of the TDP packages before they were released to the supplier.  The VAST team also identified additional savings opportunities such as providing scripts to convert files to a common format, email notification of data receipt from InSync, and an import capability to local ERP system (Global Shop) from InSync,.

### 4.6.1 Metric Capture for Business Case Development

The STEPwise supplier submitted two spreadsheets to the VAST team documenting and validating the information identified during the Value Stream Mapping event.  Both spreadsheets address the current and future processes and were used to capture metrics data for the business case.

The SME captured data on a Request for Quote (RFQ) package using the current process identified in the VSM.  This information was used to create the baseline for the business case.  They also captured data on the same RFQ package using the future process.  This information was used in the business case to caculate the savings between the two processes.

In a series of subsequent events, the SME followed a similar approach for capturing data on the current and future processes for a Purchase Order (PO) package.  This information was also used in the business case portion of the VAST program to identify savings.

### 4.6.2 Supplier Lean Engagement Lessons Learned

During the supplier engagement of the STEPwise process, including interaction held during the Kaizen events, the realization of several lessons learned further enhanced the productivity of the VAST program.  Actions were taken on several occasions by various team members to take advantage of these noted lessons and are summarized in the following sections.

### 4.6.3 Software Installation

After the completion of the software training, the SMEs attempted installation of InSync and other STEPwise tools for use in processing STEPwise packages.  Although software installation

at the SMEs site was successfully completed, there were several issues that had to be resolved before the suppliers were ready to process technical data packages.

- InSync could not initially decrypt packages using the version of PGP installed at the SME. This issue was initially resolved via an InSync configuration change, but eventually LM Aero migrated STEPwise to a secure access web site which eliminated the need for PGP altogether.
- An SME did not want its LAN exposed to the Internet (i.e. machines with Internet access were not connected to the internal LAN), so VAST worked through a process of downloading the packages, moving the packages to the LAN, and then processing the packages.
- An SME originally installed InSync and its vault (which contains the native file documents, drawings, etc. that are part of the product definition) on a non-shareable disk. Because multiple people required access to the product data contained in the technical data packages, the SME purchased a new network drive and then moved InSync to the shareable area.
- Although vault setup is automated, an SME encountered vault setup problems when they moved their InSync installation to a network drive configuration. InSync Vault management has been significantly improved in the current version of InSync.

While it is not atypical for SME's to encounter these types of problems related to software installation and setup, they can be perceived as "show stoppers" on the migration path to receiving and using digital data. Access to knowledgeable personnel is critical in overcoming these types of problems and the VAST team was able assist the SME in this case. This problem, while not complex, is so pervasive with SME's in the lower tiers of the supply chain that a new project is being led by ATI on Enabling STEP Suppliers to put a set of web accessible processes in place to assist suppliers to get started in receiving digital data in STEP format from DoD primes.

### 4.6.4 LM Aero STEP Translator Enhancements

LM Aero enhanced the existing production translator code, developed for the PAS-C program, to assure accurate Technical Data Package (TDP) STEP file generation. The enhancements addressed the handling of external files and their MIME types to assure proper identification and association to the product structure in the TDP submittals. Other enhancements have been incorporated that validate the product structure within the STEP file and how key metadata identified in the mapping events can be conveyed for use in downstream functions.

During the Value Stream Mapping event the team discovered significant inefficiencies related to the use of one of the free viewers used for viewing of raster TIFF images included in the digital data package provided by LM Aero. Although this software is not part of the toolkit provided by the VAST program, the team members investigated and found a low cost, viewer solution from Spicer Corporation called Imagination. The SME has evaluated this viewer with positive results and was purchased and used on the program.

### 4.6.5 STEPwise Refined

During the initial supplier VSM and subsequent Kaizen events, several areas of improvement were identified in the STEPwise TDP's that LM Aero was producing. Several of the focus areas dealt with how various TDP elements were associated in the STEP file to the part within the product structure. As an example, one area of interest included the association of a particular drawing sheet to a part. When dealing with a drawing containing many sheets, a great deal of time may be expended attempting to locate the part on the drawing. This led to suggestions from the suppliers for the need for the addition of data available in LM Aero information systems to be included in the digital data. This included the addition of drawing zone information (which would also assist in locating part definitions on drawings), material finish codes, and material specification callouts. Another suggestion from the SME was to assure that LM Aero defined part specifications be included in the TDP along with proper association of those parts in the product structure.

LM Aero developed and incorporated several modifications to their translation software to provide for these modifications. The final result of these efforts provided for:

- An indentured parts list in the STEP file.
- Proper association of TDP elements to the product structure components.
- Inclusion of part information in the STEP file such as material finish codes, drawing zones, and material specification callouts.
- Corrected identification of physical files and their MIME type.
- The enhancements suggested by the SMEs.
- Provided additional link between the RFQ and the TDP's.

The valued result of these TDP enhancements was demonstrated at the supplier's site through the use of InSync software. InSync interpreted the corrected STEPwise TDP's and displayed information to the user, not previously provided, in an organized and efficient manner.

Another considerable enhancement in the STEPwise process that was realized during this program was LM Aero's migration from a traditional FTP site to a secure access web site. This new capability removed the requirement of encrypting the physical data packages and placed the encryption requirement on the secure data connection. The value seen in this was a significant reduction in processing time at LM Aero as well as at the supplier's site during the package import phase into InSync.

### 4.6.6 SME Cultural Issues

As a result of the VAST program, the participating SME's came to the realization that through a cultural change of past processes, business benefits would be seen through the expanded implementation of the STEPwise process at their site. By the migration to an environment that harbors the handling of technical data in a digital form (versus paper), the supplier could become competitive and efficient in their ability to respond to RFQ's and PO contracts more expediently. As a by-product of this approach, a better quality and priced product would be delivered in a reduced timeframe back to LM Aero. In return, the supplier will have the capability of accomplishing more work with reduced manpower levels through the use of this newer technological approach.

Also, as the supplier adapts a more sophisticated means of addressing their business needs, their status as a preferred supplier would demonstrate an increased business capability and leverage their position in the marketplace. As more prime contractors follow this direction towards a digital distribution of technical data using standards, these suppliers become poised to compete for more work whereas those suppliers who have yet to endeavor into this arena are left with the burden of overcoming implementation and learning curve factors to attain the same levels of capabilities.

As was seen during the last SME Kaizen event as the VAST team worked through the PO process, the supplier's user community saw how this enhanced approach, using digital data, could assist them in their work. Technical team members at the SME as well as the President of the company immediately saw how the enhanced STEPwise packages provided a means of navigating through a TDP to make key decisions in both the RFQ and post PO award processes. Further discussion focusing on downstream activities at the supplier outside of the original intent of the STEPwise process identified some other automation opportunities. This included the extraction of a digital form of the Bill of Material (BOM) to assist the population and generation of planning data on the supplier's internal planning and shop floor work management system.

Strong management support and insight into advanced techniques for working with their customers have leveraged several LM Aero suppliers to future work as LM Aero progresses with the implementation of technological advances in the development of product definition data. This attitude was seen on the VAST team of suppliers and further validated the importance of this technological philosophy.

## 4.7 VAST STEPwise Business Case

### 4.7.1 Introduction

The VAST program objective, under the broader Small and Medium Enterprise (SME) Initiative, is to demonstrate advanced supplier development concepts with 2nd and lower tier suppliers and to validate the benefits of this interaction. DOD Program cost cutting initiatives are creating a continuing pressure for contractors to provide goods and services better, faster and cheaper.

The STEPwise information exchange methodology provides a tool to enable SMEs to meet these pressures. STEPwise is a technology that enables significant cost avoidance for SMEs. The VAST project is an example of applying lean manufacturing techniques "above the shop floor". The STEPwise technology itself is an excellent example of what is known in lean circles as "jidoka" or autonomation. This business case discussion shows that STEPwise has the capability of substantially improving the SME business practices of responding to RFQs and POs. The financial results are excellent and indicate that future implementations of STEPwise are needed in the SME community in order to meet future cost reduction targets.

### 4.7.2 Industry Trends

The VAST business case provides a success story validating the superiority of STEP standards based digital data exchange with the STEPwise principles and methodology over conventional manual methods. The VAST results document a powerful tool for reducing Air Force procurement costs. Furthermore, STEPwise will increase supplier competitiveness in non-military settings, thus fulfilling the Dual Use philosophy that is so important in today's procurement environment. Electronic Data Interchange (EDI) and eCommerce is proving to be a major competitive issue for companies who are 2nd and 3rd tier suppliers in the commercial sector.

As evidence of this development, the "Big Three" U.S. automakers are requiring their 1st tier suppliers to receive product design data and communicate with them electronically. An industry insider stated "while 80 percent of Tier 1 suppliers use EDI to communicate with the Big Three, that number falls to 30 percent for Tier 2, and all the way down to 2 percent for Tier 3". Clearly, EDI costs -- including maintenance costs as well as IT infrastructure -- have proven to be a barrier for many suppliers interested in transacting with the Big Three, forcing them to rely on phone, fax, and e-mail instead."[viii] Notwithstanding, the VAST STEPwise results clearly shows that electronic product data interchange is a viable and cost effective technology for SMEs.

The results from applying the STEPwise methodology are particularly encouraging. These new EDI and eCommerce technologies are becoming more important with the customers who recognize the need for more sophistication, accuracy and cost avoidance.

### 4.7.3 Customer Issues

The airframe manufacturers including LM Aero are developing more sophisticated supplier management strategies and demanding of their suppliers. Additionally, manufacturability is a major cost driver. The VAST data shows that utilization of the STEPwise methodology reduced the time and associated labor for answering Requests for Quotes (RFQs) and for Purchase

Order(PO) processing by 44%. These cost avoidance measures apply directly to reduce manufacturing costs. Another advantage to sharing part data electronically is data accuracy. The STEPwise technical data packages (TDPs) draw the required data components directly from the prime data warehouses ensuring that all components (design versions, associated specifications, etc.) are up to date and 100% accurate at the time of delivery. Paper-based TDPs often include old versions of data and require hours of validation both on the preparation and receiving end to “get the package right”. Accuracy effects of these mistakes are difficult to quantify. However, that doesn’t mean we should discount them.

STEPwise technology also reduces the time required to find the part that the airframer is requesting for bid. The airframers send complete sets of drawings that must be searched for the part in question. Manual search of several pages of drawing sheets can take 3-4 hours. With the STEPwise software, the TPD can be searched by part number and the needed drawing and zone found in seconds. Furthermore, STEPwise part representation lays the foundation for further supplier automation and the use of the digital data in downstream applications such as automated CNC code generation. All these benefits result in immediate and long term cost avoidance. The VAST STEPwise results clearly shows that the SMEs are capable of taking advantage of the STEPwise methodology.

#### 4.7.4 Business Case Objectives

The purpose of the VAST program is to help drive affordability concepts throughout the defense industrial supplier base by stimulating and validating improvement in small and medium sized enterprises as a result of supplier development initiatives. The VAST program’s STEPwise efforts validated the benefits associated with the use of digital product data exchange with the lower tier SMEs in the F/A-22 supply chain.

#### 4.7.5 Solution Description

For too long, U.S. civilian and military leaders have minimized the need to support developing and implementing new manufacturing systems technology. The VAST supplier development initiative is a step in the right direction and is driven by the need to reduce cost and cycle times. All organizations have too much waste in them and the techniques of lean and STEPwise reduce that waste.

In order to show the power of STEPwise principles and methodology, the VAST team conducted a detailed Value Stream Analysis of the RFQ and PO processing within the selected “STEPwise Supplier’. The ‘as-is’ proposal processes were captured and team members reviewed the data for accuracy. Once the baseline data was established, specific kaizen (improvement) events were performed to help the supplier improve on specific selected areas within the process. This data was captured and segregated into ‘before’ and ‘after’ scenarios in an effort to document the savings from the lean event. The raw data is provided in appendix A and summarized in the following cost benefits section.

#### 4.7.6 Cost and Benefit Analysis

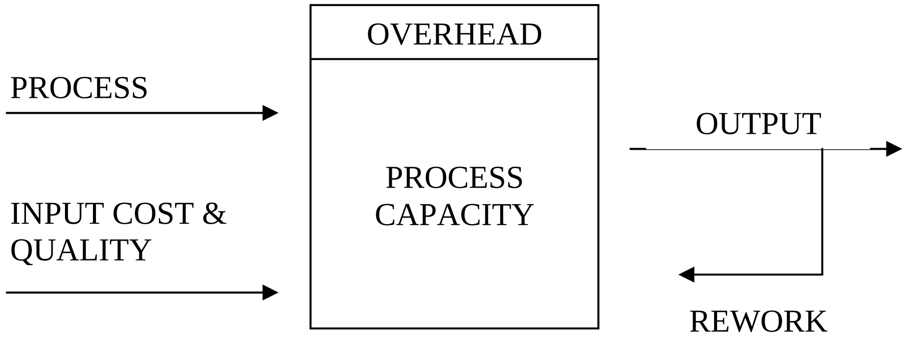



**Figure 25 Components of Operational Savings in the Bidding Systems Process**

The VAST team worked with one 2nd tier supplier to demonstrate the benefits of reducing bidding process times using the product data exchange with the STEPwise methodology. STEPwise reduces cost proposal preparation cycle time. Figure 25 shows the operations components that provide savings when the STEPwise methods are applied. The principle benefits that result in operational savings are

- Reduced process load (less manual work coming into the process either new or rework)
- Improved input quality and reduced input costs.
- Increased process capacity
- Reduced process overhead, and
- Reduced defects (improved bid quality and reduced communications.)

## 4.7.6.1 Process Load

*Process load* is the amount of work in a process that requires human intervention. For bid preparation this load primarily includes information processing including searching and interpretation. However, these loads also include unnecessary work. For example, in processing product information, the reduction of paper processing is a reduction of process load. Electronic data exchange using the STEPwise methodology reduces unneeded process steps and reduces time for those steps that are needed. The VAST project results demonstrate that the STEPwise methodologies will reduce bidding process loads for suppliers by 44%.

The VAST team performed STEPwise improvement events at one SME F/A-22 supplier. The analysis reduced the monthly RFQ process cycle time from 225 to 126 hours or a 44% reduction. STEPwise also reduces Purchase Order processing. An analysis of the monthly PO process cycle time showed a reduction from 221 to 126 hours also a 44% reduction. Industry benchmark information about product data processing with STEPwise is not known. However, the 44% reduction in processing time represents a significant cycle-time savings for supplier bid proposal development that will enable quicker and more comprehensive evaluation of cost proposals by the customer. This cycle-time reduction means improved customer service and reduced waste.

#### 4.7.6.2 Input Quality and Cost

*Input quality* is the quality level of information received from suppliers. By improving data interchange accuracy STEPwise significantly improves the quality of product information exchanged between supplier and customer. Reviewing and disseminating part information electronically speeds the internal processing and analysis.

#### 4.7.6.3 Process Capacity

*Process capacity* represents the amount of work a process can handle with a given set of resources. STEPwise improvements in process capacity will allow 2nd and 3rd tier suppliers to increase their bid preparation work volume without hiring more people (e.g., it will allow them to perform existing work loads with fewer resources). The STEPwise implementation conducted by the VAST team showed both reduced cycle times and the elimination of non-value added work in bid proposal preparation and PO processing. These results substantially increase a supplier's bid proposal and purchase order preparation capacity.

#### 4.7.6.4 Process Overhead

The VAST team showed that the STEPwise methodology reduced the cycle time of both the overhead activities of proposal preparation and purchase order processing by 44%. Bid proposal and PO processing are considered overhead activities. When queried, the SME reported that these overhead activities were "nearly identical" for every customer that they work with. Since the majority of their workload is associated with providing parts for DoD weapons systems, it can be assumed that these benefits in overhead reductions could be extended across all of their workload.

### 4.7.7 Financial Assessment

The business case represents an accumulation of input from a current supplier to the F/A-22 program and includes man hour estimates for specific technical data processing tasks, average man hour costs, and projections for future technical data exchange savings. The projected savings for the supplier was many times more than the cost of deployment. Cycle time reductions may have a more significant impact. Remembering that the end customer for the F/A-22 aircraft is the warfighter, a reduction in cycle time could mean that four aircraft, rather than three, are available for deployment when they are needed in the theater.

The project results were calculated for both the RFQ and PO processes. Each set of activities shows cycle time reductions and cost avoidance for the single selected supplier and the F/A-22 parts currently processed. The selected supplier also provides similar parts for Lockheed Martin on five other fighter aircraft. Results have also been extrapolated to address these programs. In addition, sixty-three total suppliers have been identified as providing F/A-22 parts in the same part families as those delivered by the selected supplier. As such, business case results have also been projected across this known supplier base.

The following tables summarize the results of the F/A-22 SME STEPwise engagement and estimate the impact on the F/A-22 program throughout the SME supplier base. The total annual cost avoidance is an estimate based upon the VAST STEPwise engagement for the single SME supplier who participated in the VAST program. Unfortunately, program budget cuts eliminated

plans to involve more SME suppliers. The tables also show a rollup of cost avoidance among 63 *known and identifiable* SME suppliers. The number of purchase orders (PO) processed is a function of the number of requests for a quote (RFQ) that are received and processed.

***Table 5. VAST Selected SME (single supplier ) – Annual RFQ Labor Costs***

| Annual RFQ Processing | Total Part #'s Processed | "As is" Direct Labor Hours | VAST Enabled Direct Labor Hours | "As is" Direct Labor Cost (@ $65/hr) | VAST Enabled Direct Labor Cost | Annual Cost Avoidance (@ $65/hr) |
|---|---|---|---|---|---|---|
| F/A-22 RFQ's | 246 | 56 Hours | 36 Hours | $3,640 | $2,340 | $1,300 |
| F/A-22 PO's | 82 | 2,009 | 1,640 | $130,585 | $106,600 | $23,985 |
| **Combined RFQ/PO Cost Avoidance F/A-22 Program** | | | | | | **$25,285** |
| All LM Fighter RFQ's | 2289 | 522 Hours | 348 Hours | $33,930 | $22,620 | $11,310 |
| All LM Fighter PO's | 755 | 18,498 | 15,100 | $1,202,370 | $981,500 | $220,870 |
| **Total Cost Avoidance All Lockheed Martin Fighter Programs** | | | | | | **$232,180** |

***Table 6. Sixty-three F/A-22 Sheet Metal Suppliers – Annual RFQ Labor Costs***

| Annual RFQ Processing | Total Part #'s Processed | "As is" Direct Labor Hours | VAST Enabled Direct Labor Hours | "As is" Direct Labor Cost (@ $65/hr) | VAST Enabled Direct Labor Cost | Annual Cost Avoidance (@ $65/hr) |
|---|---|---|---|---|---|---|
| F/A-22 RFQ's | 10,332 | 2,268 Hours | 1,512 Hours | $147,420 | $98,280 | $49,140 |
| F/A-22 PO's | 3,402 | 83,349 | 68,040 | $5,417,685 | $4,422,600 | $995,085 |
| **Combined RFQ/PO Cost Avoidance F/A-22 Program** | | | | | | **$1,044,225** |

***Table 7. VAST Selected SME (single supplier ) – Annual RFQ Cycle Time***

| Annual RFQ Processing | Total RFQ's | "As is" Cycle Time | VAST Enabled Cycle Time | Projected Cycle Time Reduction |
|---|---|---|---|---|
| F/A-22 RFQ's | 6 | 1,350 Hours | 756 Hours | 44% |
| All LM | 56 | 12,600 Hours | 7,056 Hours | 44% |

| | | | | |
|---|---|---|---|---|
| Fighter RFQ's | | | | |

***Table 8. VAST Selected SME (single supplier ) – Annual PO Cycle Time***

| Annual PO Processing | Total Part #'s | "As is" Cycle Time (per PO Package) | VAST Enabled Cycle Time | Projected Cycle Time Reduction |
|---|---|---|---|---|
| # F/A-22 PO's | 246 | 221 hours | 126 Hours | 43% |
| # All LM Fighter PO's | 2289 | 221 Hours | 126 Hours | 43% |

## *4.8 STEPwise Implementation Issues*

The VAST program STEPwise implementation project clearly shows the value of applying STEPwise methodology in the LM supplier base. In order to realize the benefits, these 2$^{nd}$ and 3$^{rd}$ tier suppliers will need training and support in STEPwise tools and methodology. Further, to realize the cost avoidance and cycle time reduction benefits of STEPwise, someone will need to provide support for these 2$^{nd}$ and 3$^{rd}$ tier suppliers who can't afford to develop their own STEPwise systems. While the incremental hardware costs are minimal, the current pricing structure of the STEPwise software, training and maintenance may cause SMEs to determine that the software is cost prohibitive.

The estimated initial first year investment needed to implement STEPwise includes purchasing the STEPwise software and appropriate storage space for installation and file storage. Current computer storage costs are negligible. However, at present the full software license cost of $21,000 (for 3 "seats") plus $4,200 per year maintenance is a significant investment for a typical 2$^{nd}$ and 3$^{rd}$ tier SME supplier. However, establishing common tool platforms may enable bulk license agreements from STEPwise software vendors thus reducing per unit costs. This approach can significantly reduce STEPwise implementation costs across the F/A-22 supply base and should be explored.

The VAST project clearly shows that implementing the STEPwise methodology makes good business sense for an SME. However, a lesson learned during the project showed that as with any change in doing business, there are specific change management steps that need to be followed. These steps are discussed below.

**Create a sense of urgency.** The SME must be convinced that implementing STEPwise will be a major factor in his competitive situation. Lockheed Martin's Aeronautics Material Management Center (AMMC) and its STAR preferred supplier program should incorporate STEPwise as part of its supplier evaluation criteria. Since 1995, this program has successfully improved and reduced the supplier base and suppliers are eager to participate. ATI should also be involved with its STEPwise training program. This program is well developed and ready to deploy.

**Put together a strong team to direct the process.** The Air Force/DoD should commit to STEPwise and team with the Advanced Technology Institute and their strategic business partners to create the team to train and support the SMEs implementation of STEPwise. They should develop appropriate training materials and provide the training tailored for the SMEs. ATI has already developed a STEPwise training program that can easily be expanded to accomplish this.

**Communicate the Vision.** While the vision of electronic data exchange is widely known among major corporations and software vendors, it should not be assumed that this vision is understood by the SMEs. The VAST team and ATI understand what is needed to "implement the STEPwise solution" to the SMEs .

**Empower employees to act on the vision.** Depending upon the size of the SME, computer sophistication can vary widely. This level of computer sophistication will determine what and how much training is needed to develop the appropriate employee skills. Employee training needs are often minimized, but should not be. Appropriate training means the difference between success and failure.

**Produce short-term results to gain credibility.** The VAST STEPwise project demonstrated that short-term results (both cost avoidance and cycle time reductions) are readily attainable. The project has created a supplier engagement methodology that can be easily applied to the SME supplier base.

**Build momentum for the tougher projects.** There is "low hanging fruit" that can be "picked" during the initial engagement phases of STEPwise implementation. This is critical because early success will build the confidence of the SME and will enable them to continue improving their RFQ and PO processing. However, further cost avoidance projects will not be as easy as the early ones. The customer and airframer should continue to provide support to the supply base to help them achieve greater efficiencies.

**Anchor the new behavior in the organizational culture.** Continuous improvement demands that people never stop trying to get better. After the initial projects and training, follow up training for current and new employees must be conducted on a regular basis. The more new behavior is reinforced the more likely it will continue.

## 4.9 STEPwise Critical Assumptions and Risk Assessment

The VAST STEPwise project implementation assumes that the prime contractors and the 1st tier suppliers will utilize the ISO 10303 STEP standards. This critical assumption is based upon the

fact that eCommerce is growing throughout the commercial and military sector and those who are not enabled for this technology will not be competitive. The project also assumes that 2$^{nd}$ and 3$^{rd}$ tier suppliers will be able to acquire the appropriate STEP tools and the assistance in installing and implementing this technology. Some of this assistance will come from the software industry marketing the STEP tools. However, other outside assistance will be needed to change the current bid process and purchase order procedures to STEPwise within the 2$^{nd}$ and 3$^{rd}$ tier supplier community. This assistance is absolutely necessary to achieve the cost cutting targets in today's procurement environment.

The downside risk is that government decision makers will view STEPwise technology as a "problem-solved" that requires no more support. While the STEPwise technology is mature and well tested, the implementation issues associated with wide deployment with the SMEs in the DoD industrial base are still ahead. Implementing lean principles requires discipline and perseverance. Much more support from the Government is needed to ensure that this important technology becomes anchored in our SME business practices.

## *4.10 STEPwise Conclusions and Recommendations*

The whirlwind of mergers and acquisitions among first-tier manufacturers has begun to spread downward into the 2nd and 3rd tier of suppliers all of whom find themselves with an increasingly narrow customer base. Though consolidation among the 2nd and 3rd tier is seemingly inevitable, that alone is not enough to guarantee survival. Companies must redouble their efforts in implementing effective performance improvements through proven world-class tools that promise cost, quality, delivery and technology improvements.

The world is quickly moving towards a fully digital business environment. Many companies have paper reductions initiatives that are driving the digital approach. Lockheed Martin is converting to digital Technical Data Packages for other reasons - competitiveness! The STEPwise initiative is a major component in the future of digital data exchange with the supplier base. STEPwise utilizes a number of ANSI, ISO and Industrial Standards and vendor Commercial-off-the-Shelf (COTS) software packages to achieve flexible digital data exchange of technical data and bid package data throughout its supply chain.

The VAST program has demonstrated a number of potential and realized improvements to processes and methodologies as well as validating the tremendous business gains that can be realized through the commitment towards a digital world as supported through STEPwise. Many opportunities exist beyond the current implementation of STEPwise and other initiatives that LM Aero has ventured towards in conjunction with their supplier base. The VAST team has merely tapped into this potential and it can be seen that future development and deployment must be supported to enable the F/A-22 and other Air Force programs to reap the full benefits.

# 5 Gainsharing

## 5.1 What is Gainsharing?

In the traditional sense, gainsharing involves groups of employees of a company who strive to improve a company's performance through better use of labor, capital, materials, etc. In return for their employees' efforts, the company shares part of the resultant savings from performance gains in the form of a cash bonus, the amount of which is calculated according to some predetermined formula. The bonuses are based upon group performance rather than individual performance. Although gainsharing has become quite popular in recent years, it is not a concept that is new. In fact, the original concept goes back to the Scanlon Plans of the 1930's.

The business model the VAST Program operates is different than the "traditional sense". The primary difference is the business interactions are not within a particular company but between companies in a supply chain. This situation is compounded by the fact that in a supply chain, direct relationships only exist from one level to the next. As such, LM Areo maintains a contractual relationship with their first tier suppliers, but has no direct or contractual link to second, third, and lower tier suppliers. This situation will produce different dynamics since those involved will typically align their allegiance to their particular company with little concern for those organizations not perceived as having a direct impact on their company.

## 5.2 VAST Gainsharing Goals

The goal of the VAST program is to structure a gainsharing approach that enables all members of the supply chain to share in the benefits. The Lean Supply Chain Management initiative offers potential sharing of savings through cost reduction efforts, while the STEPwise initiative offers benefits through technology insertion and resultant cost savings. The VAST Program documented the various approaches to Gainsharing that are available within industry.

Since any gainsharing approach may vary with the circumstances of a given program/project, specific guidelines will be developed to ensure all supply chain members are treated fairly and consistently. The VAST Program gainsharing approach takes into consideration the amount of savings subject to sharing, measurement/validation of the savings, and the implementation approach.

## 5.3 Gainsharing Current Approaches – Project Types

When the VAST proposal was put together, there were several proposed gainsharing strategies being pursued (see Figure 26 below) as part of several projects by Lockheed Martin Aeronautics' Lean Supply Chain Management Initiative. The "Proposed Sharing Guidelines" were in various stages of implementation at that time. As time passed, some worked as planned, some did not work, and some approaches changed. A look at each project type and associated pros and cons follows.

| Project Type | Proposed Sharing Guidelines |
|---|---|
| Product improvement (value engineering) | • Non-recurring implementation costs will be absorbed (unless program funding is available).<br>• Once the cost of implementation has been offset (e.g., by maintaining pre-VE pricing until non-recurring cost are recovered), the cost reduction will be shared on a mutually beneficial basis (normally a 50/50 share ratio).<br>• Where a program target cost has been established, savings will not be shared until the target cost is met. Where the supplier price is below the target cost, the supplier may retain up to 100% of the amount below the target cost (depending on the degree of customer non-recurring funding requirements).<br>• Generally, savings will not be shared where Lockheed Martin or the Government fully funds the supplier non-recurring requirements. |
| Process improvement (kaizen) | • Target cost reduction in exchange for the facilitation of three structured kaizen continuous improvement events. The supplier will retain savings below the target cost. |
| Group Purchase Agreement (GPA) | • Suppliers retain the profit on the cost of the material.<br>• The amount of cost reduction is not shared with the supplier, but passed through to customers. The supplier incentive is the retention of profit dollars at the pre-GPA level. |

**Figure 26. Proposed VAST Gainsharing Summary**

### 5.3.1 Product Improvement / Value Engineering

"Product Improvement" addresses an existing product's specification driven form, fit, and function characteristics. Value Engineering is a conventional process, used industry-wide, that evaluates a potential change to a product that would reduce its cost without impairing essential functions or characteristics such as service life, reliability, economy of operation, ease of maintenance, and necessary standardized features. Typically, value engineering cost reductions result from design or specification requirement changes. The change is incorporated into a Value Engineering Change Proposal (VECP), which is evaluated for acceptance. The VECP can be independently submitted by a supplier, or be the result of a Lean Supply Chain Initiative Lean Event.

The primary tasks of the participants include the prime contractor who will facilitate generation of VECP's from Lean Events and evaluate the VECP for acceptance. In this scenario the supplier is responsible for the generation of the VECP projects.

The benefits (Pros) of Value Engineering are reduced product cost and reduced lead times. The downside (Cons) based on experience by Lockheed Martin and input from suppliers queried indicates very limited success with this approach. Several issues hamper the VECP generation process including that the VECP's must be written, reviewed, and executed in a timely manner in order to make them useful, the submittal rate tends to be low due to history of low acceptance rates, and most importantly that the administrative processes affected by the change (e.g. drawing changes, spec. changes, VECP process) are proved to be so costly that they offset product change savings.

### 5.3.2 Group Purchasing Agreement

A Group Purchasing Agreements (GPA) is a pricing agreement between a prime contractor and a sub-contractor or set of sub-contractors that contains negotiated pricing and terms and conditions

for required components or materials.  It has been established to allow its suppliers to take advantage of the buying power of Lockheed Martin.

Figure 27 provides a partial list of the types of components for which GPA's can apply.

| | |
|---|---|
| Fasteners | Magnetics |
| Connectors | Wire & Cable |
| Printed Wiring Boards | RF Components |
| Resistors | Capacitors |
| Integrated Circuits | Adhesives & Sealants |
| Raw materials | Cable Assemblies |

**Figure 27 Component Types**

Under a Group Purchasing Agreement the primary tasks of the prime are to provide forecasts to sub-contractor and initiate a long-term contract for the procurement of the subject components or raw materials and to provide the sub-contractors with purchase orders that require the subject components or raw materials.  The primary task for the sub-contractors are to provide forecasts of needs to the prime and to deliver parts or products that contain the subject components or raw materials.

The benefits (Pros) of a Group Purchasing Agreement are that the discounted cost of the material is directly passed on to Lockheed Martin who established the GPA, that the supplier has a reduced administrative cost in the requesting and processing of multiple quotes from various sub-contractors, that a supplier is allowed to incur additional savings by using GPA for components used in their other customer's parts as long as they are GPA components used in Lockheed Martin parts, and that a supplier can include their sub-tier supplier(s) to take advantage of the GPA and thus become more competitive to Lockheed Martin.

Suppliers have shown limited interest in participating in GPAs for various reasons and site the downside or Cons to the Group Purchasing Agreement approach to include not wanting to undertake take the additional effort to break out their internal part numbers into standard call-outs (e.g. AN, MS, ANSI), they don't use enough of the subject components or raw materials to meet the minimum discount quantities, that they have better pricing from their own GPA's, and that they are not aware that they are not restricted from purchasing additional quantities of materials for use on other customers parts.

## *5.4 Gainsharing Current Approaches – Sharing Strategies*

### 5.4.1 50/50 Approach.

This approach was studied as part of the “Product Improvement” and “Process Improvement” projects and applies to existing contracts. Non-recurring implementation costs will be absorbed (unless program funding is available). Once the cost of implementation has been offset, the cost reduction will be shared at a 50/50 ratio. Where a program target cost has been established, savings will not be shared until the target cost is met. Where the supplier’s price is below the target cost, the supplier may retain up to 100% of the amount below the target cost. Savings generally will not be shared where someone other than the supplier funds supplier non-recurring requirements.

### 5.4.2 Memorandum of Agreement (MOA).

A Memorandum of Agreement is executed between two parties to document an agreement that will result in a contractual change in the near term. This approach was studied as part of the “Process Improvement” project and applies to an existing contract. As a result of a supplier’s Lean activities or in exchange for Lean training and Lean events by the customer, a supplier will sign a MOA lowering the cost of an existing contract. If a target cost exists, the supplier will retain any savings achieved below the target cost during the duration of the contract.

### 5.4.3 Fact Finding & Negotiation Support

This approach applies during the fact finding and negotiation phases leading to a new contact. A supplier’s Lean activity is evaluated to determine:

- Potential cost savings from instituting Lean implementation
- Cost savings attributed to past Lean implementation
- Potential cost savings from continued Lean implementation

An agreement is reached and the cost savings becomes part of the new contract. If a target cost exists, the supplier will retain any savings achieved below the target cost during the duration of the contract. As part of the agreement, the supplier could request Lean training and Lean events.

## *5.5 Gainsharing Contractual/Legal Issues:*

Contractual and legal issues may also inhibit gainsharing approaches. If the contractual issues become too cumbersome, many companies find the additional time and money spent in complying with the contract clauses offset any savings. The situation could exist where the issues could prohibit gainsharing all together.

In the aerospace industry, the following types of sales are most commonly transacted:

1. Direct Government
2. Foreign Military Sales (FMS)
3. Commercial

These sales are administered with firm-fixed-price (FFP) and cost-plus types of contracts. Cost-plus contracts are becoming less common. Because of their prevalence in the industry, firm-fixed-price (FFP) contracts are focused on in the following discussion. Legal review indicates that regulations affecting FFP contracts for the three types of sales noted above would not constrain any of the gainsharing approached noted previously.

The scenario that needs further review would be a FFP contract for a Direct Government sale or FMS that has Truth In Negotiation Act (TINA) regulations invoked due to the value of the contract exceeding $550K. Two situations could occur during the negotiation phase:

1. If savings associated to a process improvement (e.g. Lean, STEPwise) is a certain percentage, with none going back to the supplier, then it will be declared per TINA rules and would be interpreted as a direct savings to the customer.

2. If savings associated to a process improvement (i.e. Lean or STEPwise) is a certain percentage, with some going back to the supplier via a gainsharing approach, then it will be declared per TINA rules and will require approval by the Government.

FFP contracts would motivate a supplier to make process improvements because they could keep all the extra profit because they have no obligation to notify their customer. This scenario is good for the supplier but no benefit comes to the customer unless the contract is large enough to be impacted by TINA. When a new contact is to be negotiated, then TINA requirements would reveal the lower costs and resultant lower prices. If TINA is not in effect, then only normal competitive pressures would lower prices.

## *5.6 Gainsharing Business Issues*

When a supplier has achieved, or expects to achieve savings, there are business issues that affect disclosure of those savings:

- Competition
- Adversarial or “arms length” relationship
- Limited information exchange
- Sole source situation
- Percent of supplier’s business
- Contract type

The VAST suppliers were asked how the business issues could be mitigated or minimized. The simple response was to form a stable business relationship based on a long-term partnership. This would allow the supplier to have a truer picture of the needs of their customer. It would satisfy two goals that should exist for any supplier – satisfy the customer and do what it takes to be a customer’s “supplier of choice”. The supplier would be willing to make investments if they know that orders will continue. A partnership would also address the issue of increased capacity as a result of lean implementation. If the customer is filling that capacity then the overhead costs can be lowered since they will be spread out over a larger business base. It was also noted that savings are hard to quantify in the short term with small lot buys. A partnership would foster

long term agreements and multi-lot contracts, which are needed to realize benefits. A partnership would also reduce the risk of business being moved to another supplier before savings could be realized.

## *5.7 Gainsharing Results*

The VAST team considered the gainsharing data collected and concluded that some approaches had stronger potential than others. The "Product Improvement" project would not be advantageous to pursue. According to all those queried, the VECP process has not performed with significant results in practice. Customer commitment was weak and the process is burdened by too much administrative cost.

While evaluating the 50/50 ratio gainsharing strategy with the "Process Improvement" project, it was discovered that trying to document the savings from specific Lean Events was very difficult to administer by all parties involved. As such, this is also considered a weaker approach.

The shift to the sharing strategies, noted with the Memorandum of Agreement and the Fact Finding & Negotiation, used with the "Process Improvement" project proved to be much more successful in capturing savings that could be passed on through the supply chain.

The GPA activities are also advantageous to pursue. It's important for the company establishing the GPA's to set them up to allow usage by multiple levels of sub-tier suppliers. The greatest volume leverage for pricing will be achieved if the supplier base is solicited for usage prior to the request for bid process with the vendor(s). The company establishing the GPA's should aggressively promote their use with their supplier base and develop metrics that show that the GPA's are being used. Firm-fixed-price contracts do not have any requirements for costing disclosure so some form of communication during the contracting process would acknowledge use of GPA's.

## *5.8 Gainsharing Conclusions:*

A gainsharing approach that is based on tracking specific savings captured during a lean event (e.g., 50/50 ratio) is administratively prohibitive. What companies seem most likely to respond to is having a partnering relationship with their customer that provides them with realistic pricing targets. In this scenario, the supplier has the motivation of retaining all the savings after the target has been achieved. The motivation of the supplier is also enhanced with the customer providing assistance with Lean training and cooperative Lean events. The partnering would work to the greatest extent if the customer can provide additional business as Lean implementation is freeing up supplier capacity. Current contracting regulations could still exist and the contracting process between the parties would flow more rapidly with open channels of communication.

# 6 Conclusions

There are several conclusions that can be drawn from the data and experiences that were collected during the VAST Program. The following sections have grouped these recommendations into three broad categories.

## *6.1 Lean*

Lean investment by the Prime contractor in the supply base (SME or other) has to be motivated by a business driver. Prime contractors are motivated to invest in Lean when:

- A SME supplier supports multiple prime contractor programs and the benefit is easily quantifiable to the prime contractor
- When cost becomes critical to a specific program that the SME is supporting
- Lead-time becomes critical to a specific program that the SME is supporting.

The SMEs do not have the infrastructure to invest in Lean without prime contractor or government support. The SMEs are not willing to take on the full cost of:

- The hardware or software investments
- Lean training, unless they have to (through prime contractor pressure competition, or other business forces)
- There is a very short Return on Investment

One-on-one SME Lean engagements by the prime contractors are not feasible to cover the entire DoD industrial base by prime contractor's investment. The prime contractors are not willing to make the investments to lean out SME suppliers across the board. The VAST Program was able to lend credence to these conclusions from the engagements that were conducted by the VAST Program:

- The majority of SME's business was with Prime Contractor
- There was benefit for supporting the VAST STEPwise supplier because the SME does 60% + of their business with LM Aero
- Need motivators to get suppliers to support Lean (e.g., crisis, competition, survival, etc.).
- For VAST, the suppliers were paid to participate directly with VAST personnel.

## *6.2 STEPwise*

The biggest conclusion that the STEPwise activity provided is that the *SME suppliers need the right TDP data at the right time.* The Business Case and Lean approach proved that this was the biggest process inhibitor for getting the correct information to the prime contractor at the right time. Accurate and complete TDP data assures that correct parts are built for prime contractor requirements. The VAST approach ensured that the SME received complete and correct data.

Complete data packages are crucial to the SME suppliers. This includes drawings, associated lists, specifications, standards, and reference documents that tie the parts together in the product structure. Other information, included Meta-data (i.e. drawing zones, finish codes) can produce significant savings in labor to review, evaluate, and produce the component. The minor modifications that linked the TDP to the supplier's RFQ and/or supplier's PO were greatly beneficial to the supplier.

A common SME supplier electronic data repository will facilitate access to “correct” data. This addresses the issues surrounding document control issues (ISO 9000), multiple access to same source of information (single controlled source of information), and the electronic data provides an avenue for easier hand-off to the next person in line at the SME location.

## *6.3 Gainsharing*

Most SMEs do not have detailed cost accounting systems in place to support tracking of capital investments or labor expended for a specific task or project. Therefore, when prime contractors or government official attempt to quantify gainsharing within the supply chain, it is very difficult to quantify.

Additionally, gainsharing concepts are not well understood in the supplier community. The traditional approach to gainsharing has been internal sharing of the profits with the individuals that participated in the reductions. Gainsharing has a new meaning, sharing the reductions with prime contractor and government personnel.

Business issues also have an impact on how savings are declared and reported. The FAR and DFAR regulations provide more government oversight into the SME business than most SMEs are willing accept.

For the F/A-22 program cost targets are the current drivers for the SMEs. The F/A-22 program targets provide a cost target for each component on the F/A-22. Most SMEs are attempting to make these program targets prior to being able to even address Gainsharing. This is because savings can’t be shared until after F/A-22 program targets have been met. This is a major inhibitor to the SME’s ability to discuss or consider Gainsharing.

# 7 Recommendations

The VAST Program conclusions, contained in the previous section, contain many of the technical conclusions of the program based upon the tasks that were completed with the limited funding and the limited set of data points that were collected during the duration of the program. The following sub-sections contain recommendations to AFRL on where future expenditures need to be made. The section entitled 'Potential for Extending VAST Program Efforts' is focused on the technical aspects of extending the VAST Program.

## *7.1 Business Case Validation*

One of the precepts of the AFRL/MM SME initiative was to identify and validate the business case for SME development to the prime contractors and to the USAF. The recommendation for AFRL/MM is to fund the VAST program to complete the task of collecting sufficient data points to make a compelling recommendation on business case results at the SME level. A single data point in the Lean arena and a single data point in the STEPwise arena is not a compelling business case for industry. The results need to be on a broader scale and deployment activities need to occur for the results to be implemented. Without this investment of time and energy, the precepts of the original program will not be met.

## *7.2 Gainsharing*

The recommendation for AFRL/MM is that additional effort needs to be expended to explore Gainsharing approaches identified in the program. The VAST Program is the first documented approach to Gainsharing that has been available within industry. The information contained within this report needs to be discussed and debated on a larger scale within the DoD Industrial Base so that many of the cultural impediments can be overcome. The Gainsharing section of this document has identified several impediments that need to be mitigated through additional research and study of these opportunities. This includes identification of Gainsharing success stories that have been discussed within industry, but have not been documented on a broader scale for implementation.

## *7.3 Industrial Competitiveness*

The recommendation for AFRL/MM is that the Government (e.g., DoD and DoC) should support efforts in maintaining US business competitiveness and technology innovation for SMEs supporting the DoD industrial base. The SME suppliers that the VAST Program engaged were primarily focused on DoD business and did not have much commercial business. The DoD requirements are different than the requirements that are levied in a commercial environment (e.g., TINA).

In the STEPwise arena, DoD SMEs do not have business drivers to invest in data transfer technology. Data transfer technology is a high initial capital and personnel training arena due to the nature of the problems in transferring electronic product data between systems. But, data sets are getting to be so large that manual manipulation and management is no longer a viable mechanism for prime contractors or SMEs. The other recommendation is that the application of Lean Principles to product data transfer has the potential for widespread cost avoidance, timesavings, and quality improvements.

# 8 Opportunities For Extending the VAST Program Efforts

## *8.1 Opportunities within DoD and DoD Industrial Base*

### 8.1.1 Generalized Lean Training for SMEs

Within the SME supply community there is a need for generalized training that would benefit the general DoD supplier community. There are numerous SMEs that have limited access to lean training. Consultant offered training is typically cost prohibitive. Interactions with the prime contractor community is hindered because SMEs are usually second-tier or lower suppliers and thus “invisible” to the prime contractors who typically only identify first-tier suppliers in their supplier databases. Even at the first-tier level, the prime contractor overlooks the SMEs because their business volume with them is not high enough to warrant the training expense.

This training could be offered through several Department of Commerce initiatives that are focused on SME development. Another avenue is to sponsor the prime contractors or industry consultants who have the experience in training a large audience of SMEs on a regional basis.

### 8.1.2 Digital Data Standardization

One of the impediments of a broader use of digital engineering data within SMEs is the lack of digital data standards for the suppliers to utilize. The majority of the data that LM Aero provides to SMEs can be used as a two-dimensional drawing only because the SME cannot utilize the native CAD format that LM Aero has available from the engineering department. If the digital data were supplied in a standard format that all suppliers could read directly, the SMEs would be able to utilize the CAD system of their choice (in lieu of the format that LM Aero provides). Most of the larger contractors will only provide the three-dimensional data to a supplier in the native CAD format because most CAD Systems do not have a method to verify the accuracy and completeness of the data transmitted.

A program (or a regiment of processes and tools) needs to be developed and deployed to allow the confidence that the prime contractor and the SMEs need to utilize data in a ‘neutral’ or ‘open standards’ form such as ISO 10303 (STEP).

### 8.1.3 Digital Data Submission to DoD in lieu of Aperture Cards

On several of the LM Aero legacy contracts, the government requires submission of aperture cards for engineering data. In most cases, LM Aero can provide the DoD digital engineering data. DoD needs to modernize the organizations that are still requiring submission of aperture cards for engineering data submission. In some cases, DLA is the organization that is requiring the submission of aperture cards or raster digital files for engineering data.

A cost benefit analysis for the DoD and the prime contractor needs to be conducted to evaluate the payback to the DoD on providing digital data in lieu of hardcopy. On many of these systems, the DoD costs are rising at a higher rate than the LM Aero rate because the engineering efforts at LM Aero are complete and the DoD is starting to competitively bid replace of components. These replacement efforts are higher when utilizing the older aperture card and mylar methods

because the supplier has to re-enter the data into a CAD/CAM system for manufacturing purposes.

### 8.1.4 Conversion of Stable Base Material to Digital Data

On several LM Aero legacy programs, the original engineering was developed on stable base material (e.g., mylar) and is being retained on stable base material because of several possible problems:

1) Funding to convert the legacy data when the contractor only has a contract to maintain the data (at the requisite cost for maintenance of facilities and equipment to maintain and reproduce the material).
2) In some cases, the prime contractor is the only organization that can even make copies because the DoD does not have capability to make copies due to size of the original document, the actual stable base material type (i.e., what the material is made of precludes easy duplication), etc.

An opportunity is to provide funds to convert this data to digital. Within the DoD, there would also be a need to provide systems that could handle the converted data. The cost benefit analysis that is described earlier in this report needs to be undertaken using the same arguments.

### 8.1.5 DoD Engineering Data Systems Standardization

Almost every DoD Program has a different set of requirements for submission of digital data to the DoD. If these could be standardized, then the costs to the DoD would be reduced significantly. The DoD has standardized on the JEDMICS System, but peculiarities on a per DoD Program persist. This also drives additional LM Aero costs to maintain different interfaces to the peculiarities of the different JEDMICS installations.

## *8.2 Opportunities within LM Aero*

The VAST Program provided LM Aero an opportunity to get some unbiased feedback on the business case from the SME suppliers and an opportunity to document the different gainsharing approaches (with the positive and negative aspects) into a single document. There are several different opportunities that can be identified throughout this document. The following sub-sections discuss some of these opportunities.

### 8.2.1 Training Modules for Lean Supplier Development

There are several Lean training modules that the Materials Management organization has utilized to develop Lean philosophies within the supply chain. The VAST program allowed LM Aero to validate that these modules would work in the SME suppliers, as well as, the larger suppliers that LM Aero works with. The SME usually requires some basic Lean training to develop an understanding of the principles of Lean. Additional module training development is required for some of the SME unique requirements.

### 8.2.2 SME interface to Digital TDP Data

LM Aero is pushing the SME community to only utilize digital data (in whatever form the data is provided by LM Aero) in the production of the respective components. LM Aero provides digital data files with a naming convention that allows the supplies to identify the contents of the file (including drawing number, drawing revision, sheet, etc). Unfortunately, for larger digital

data packages, there can be thousands of digital data files that the SME has to evaluate for a single Build-to-Package. The SMEs need to be provided an interface that could be used to organize the data into a logical structure for the SME. STEPwise provides the data into a PDM System that is one method of meeting this need for the small enterprises.

### 8.2.3 System Consolidation within LM Aero

As described in other sections of this report, LM Aero has numerous disparate legacy systems that need to be combined so that the SMEs can expect a consistent engineering data package across all LM Aero programs. This opportunity will require internal process changes that are not currently feasible due to the nature of contracting that DoD has in place and the different methods that the different DoD organizations have for receiving digital data. The opportunity is to work with DoD to come up with a single system interface for LM Aero submission of digital data.

## *8.3 Opportunities within ISS*

ISS has long believed in the value of standardized, digital product data exchange and has invested heavily in supply chain solutions. The VAST Program provided ISS with an opportunity to get some unbiased feedback from the SME suppliers on the business case for STEP-based products and on the STEPwise implementation approach. The VAST program specifically targeted the delivery of Build-To-Packages (BTPs) to a small, direct supplier of LM Aero and was specifically focused on RFQ and Purchase Order processes. The general applicability of the digital product data exchange and the VAST STEPwise approach extend well beyond the scope of VAST, providing numerous opportunities for expansion.

### 8.3.1 Broad Deployment of STEPwise within LM Aero Supply Chain

While VAST collected valuable feedback from the supplier(s) that participated in the program, the number of suppliers was restricted due to funding limitations. As the VAST program progressed, it became apparent that most suppliers were largely unaware of the benefits that could be achieved through digital data exchange. A broader deployment of STEPwise within the LM Aero supply chain could be used to not only corroborate VAST results in the RFQ and PO areas, but also provide an effective means of exposing the benefits of digital product data exchange to the people that can benefit from it – both within the LM Aero supply chain and within LM Aero itself.

### 8.3.2 Extension of STEPwise beyond LM Aero Supply Chain

Because utilization of an ISO standard is at the core of the STEPwise approach, the VAST implementation should be applicable beyond the LM Aero supply chain. Although LM Aero requirements were used to drive VAST's implementation, STEPwise was intentionally developed to reduce supplier costs by offering a solution that allowed suppliers to receive and process product data from multiple customers in the same manner. Including other OEMs in military (or even commercial) aerospace in a STEPwise deployment would bolster the adoption of standardized digital exchange and help address the ongoing battle suppliers fight against having to support costly, proprietary solutions for each one of their customers.

### 8.3.3 Extension of STEPwise to Support Bi-directional Exchange

STEPwise currently supports the exchange of sophisticated product data from LM Aero to their suppliers, and VAST specifically targeted exchanges in support of the RFQ and PO processes. Incorporating bi-directional exchange capabilities would allow STEPwise to be utilized in support of other processes (e.g. design collaboration, processing engineering changes, etc.) and would allow STEPwise packages to be generated and distributed throughout all tiers of the LM Aero supply chain.

## 8.4 Opportunities within Theorem Solutions

As Theorem Solutions is a leading provider of translation services and products, in addition to their CADviewer solution, opportunities exist within the supplier base as the advanced deployment of digital data technologies occurs. The STEPwise process demonstrated the advantages and needs for the distribution of digital data from LM Aero to their suppliers. As this process gets propagated across a broader base of supplier, the needs for viable product solutions addressing CAD viewing requirements exist, but also a need will arise to allow the supplier to integrate the digital CAD models from LM Aero into their preferred CAD system. In order to accomplish this latter objective, a proven and proficient translation product offering is required. Theorem Solutions offers many options here including an on-line based translation service as well as localized licenses of the translator software products. In the case of LM Aero product data, the on-line solution may not be an option to ensure proper handling and security of the data, but this capability may prove valuable to the supplier in dealing with other contracts with different customers.

Theorem Solutions has consistently provided leading edge products and their continued involvement with LM Aero and its suppliers will allow the progression of the STEPwise technology to a more advanced stage of deployment.

## 8.5 Opportunities within ATI

ATI 's core business is designing custom-fit, public-private collaborative R&D programs for customers with unique needs. The VAST resources, management structure, organization, technical approach, use of sub-contracting, and leveraging of government and other funds was developed to meet the specific need of the Air Force on this program. They have existing tools in place that can and should be used to leverage the rapid deployment of digital product data technologies within the supplier community throughout the DoD industrial base.

[i] Commerce Business Daily Announcement Number: Broad Agency Announcement #99-4-MLK

[ii] "Supplier Development and Management: Report of the WL/MT Focused Study Team." Dayton, OH: Wright Laboratory Manufacturing Technology Directorate, 1996.

[iii] "Supplier Development: Mechanisms, Barriers, and Programs", Dayton, OH: Wright Laboratory Manufacturing Technology Directorate, 19 February 1999.

[iv] *Forecasting for Technologists and Engineers,* Brian C. Twiss, Peter Peregrinus, Ltd., 1992, p. 25.

[v] MBS2002 is the automotive industry's major outlook meeting held annually for over 30 years, August 5-9, Traverse City, Michigan. See http://www.mbs2002.org/ for details.

[vi] *Becoming lean: inside stories of U.S. manufacturers,* Jeffery K. Likert. Ed., Productivity Press, 1997.

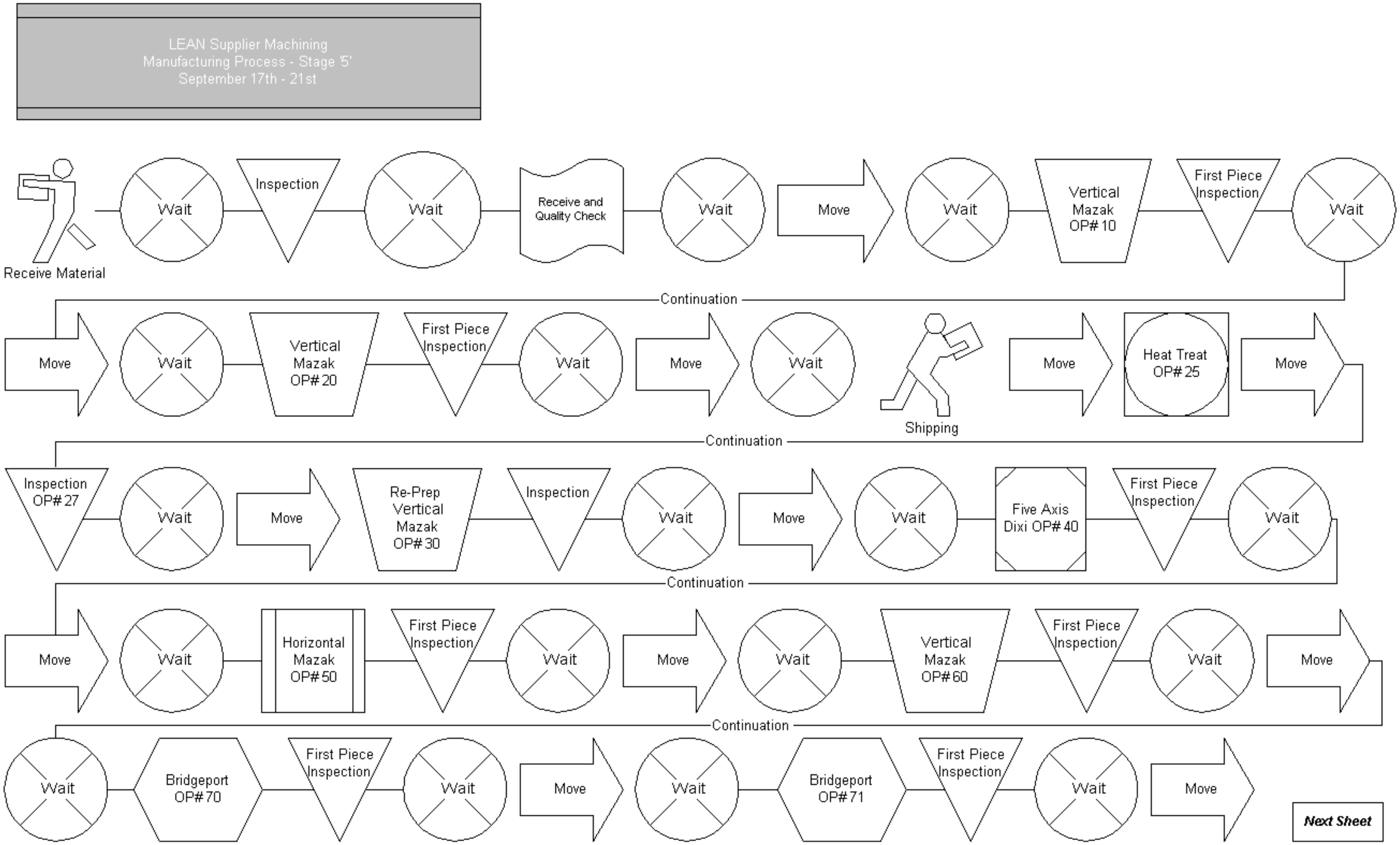
[vii] For examples, see Likert in the reference list.

[viii] Shawn Thomas, http://www.line56.com/articles/default.asp?ArticleID=3468

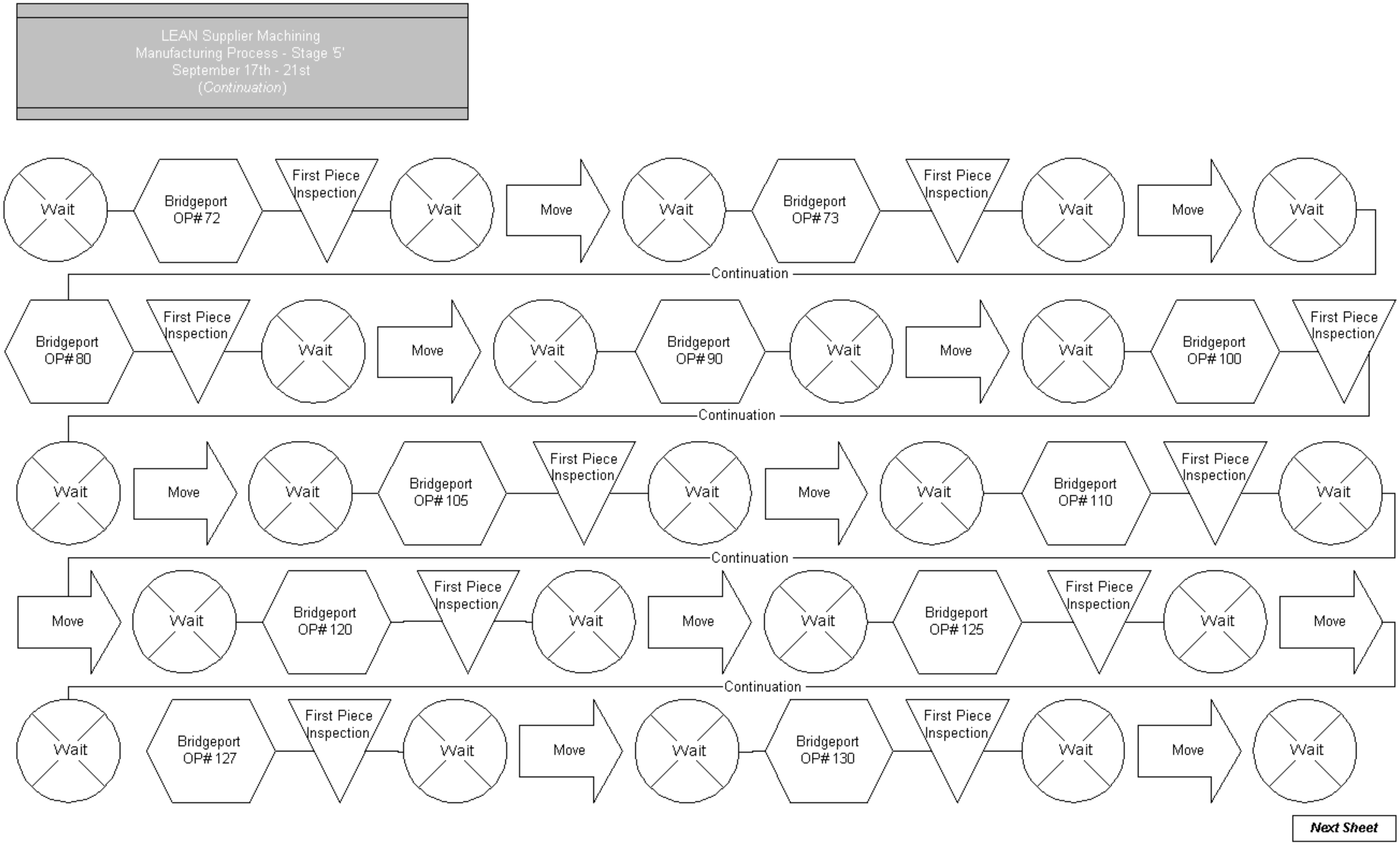
# APPENDIX

## Input for VAST Lean Supplier

The VAST team represented the Lean technique of value stream mapping using VISIO software to help the supplier identify their manufacturing processes for the F/A-22 Lower Beam. Data charts containing the raw calculations are also included.



LEAN Supplier Machining
Manufacturing Process - Stage '5'
September 17th - 21st
Receive Material
Wait
Inspection
Wait
Receive and Quality Check
Wait
Move
Wait
Vertical Mazak OP# 10
First Piece Inspection
Wait
Continuation
Move
Wait
Vertical Mazak OP# 20
First Piece Inspection
Wait
Move
Wait
Shipping
Move
Heat Treat OP# 25
Move
Continuation
Inspection OP# 27
Wait
Move
Re-Prep Vertical Mazak OP# 30
Inspection
Wait
Move
Wait
Five Axis Dixi OP# 40
First Piece Inspection
Wait
Continuation
Move
Wait
Horizontal Mazak OP# 50
First Piece Inspection
Wait
Move
Wait
Vertical Mazak OP# 60
First Piece Inspection
Wait
Move
Continuation
Wait
Bridgeport OP# 70
First Piece Inspection
Wait
Move
Wait
Bridgeport OP# 71
First Piece Inspection
Wait
Move
Next Sheet


LEAN Supplier Machining
Manufacturing Process - Stage '5'
September 17th - 21st
(Continuation)
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Bridgeport OP# 72
First Piece Inspection
Wait
Move
Wait
Bridgeport OP# 73
First Piece Inspection
Wait
Move
Wait
Continuation
Bridgeport OP# 80
First Piece Inspection
Wait
Move
Wait
Bridgeport OP# 90
Wait
Move
Wait
Bridgeport OP# 100
First Piece Inspection
Continuation
Wait
Move
Wait
Bridgeport OP# 105
First Piece Inspection
Wait
Move
Wait
Bridgeport OP# 110
First Piece Inspection
Wait
Continuation
Move
Wait
Bridgeport OP# 120
First Piece Inspection
Wait
Move
Wait
Bridgeport OP# 125
First Piece Inspection
Wait
Move
Continuation
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Bridgeport OP# 127
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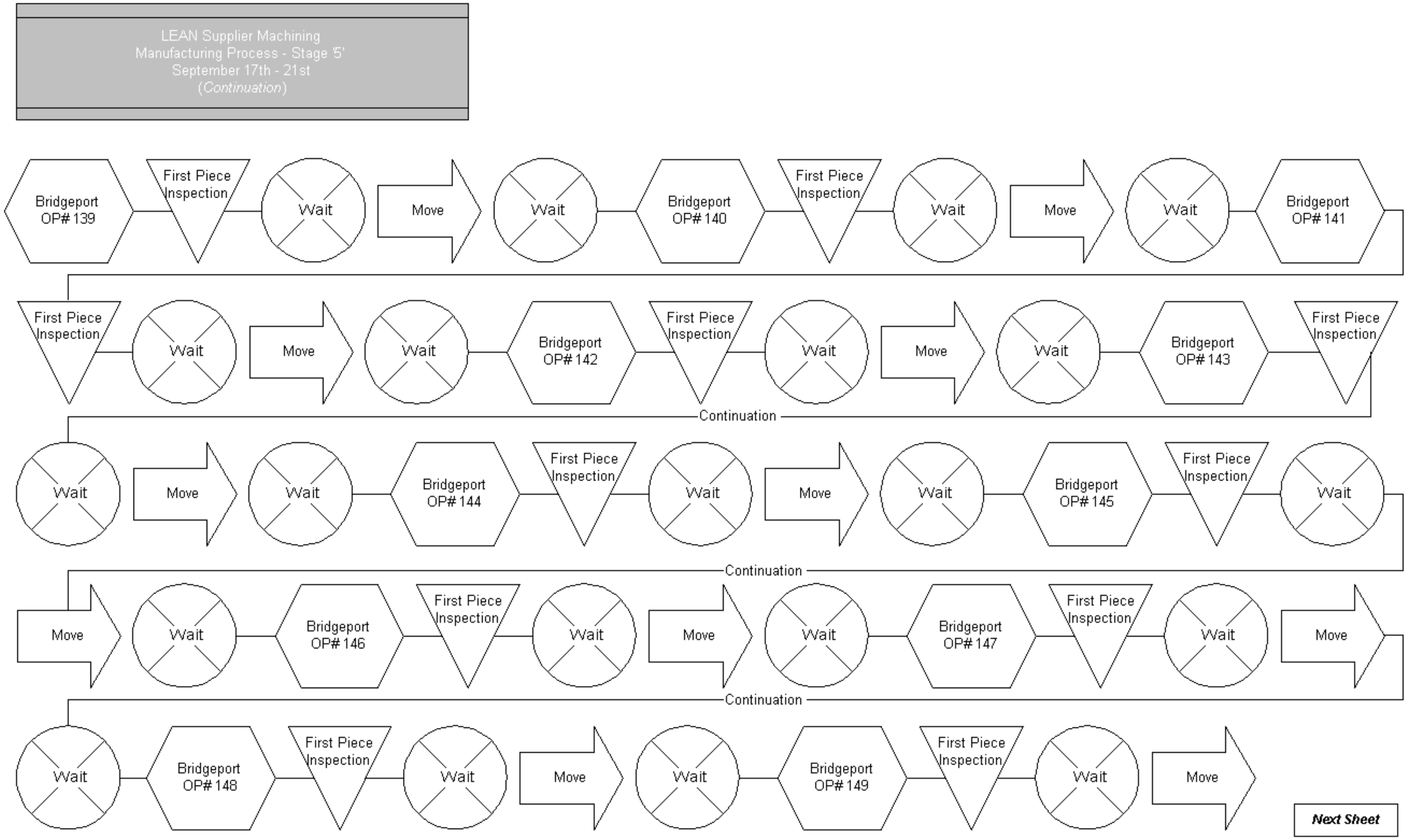
Wait
Move
Wait
Bridgeport OP# 130
First Piece Inspection
Wait
Move
Wait
Next Sheet



LEAN Supplier Machining
Manufacturing Process - Stage '5'
September 17th - 21st
(Continuation)
Bridgeport OP# 139
First Piece Inspection
Wait
Move
Wait
Bridgeport OP# 140
First Piece Inspection
Wait
Move
Wait
Bridgeport OP# 141
First Piece Inspection
Wait
Move
Wait
Bridgeport OP# 142
First Piece Inspection
Wait
Move
Wait
Bridgeport OP# 143
First Piece Inspection
Continuation
Wait
Move
Wait
Bridgeport OP# 144
First Piece Inspection
Wait
Move
Wait
Bridgeport OP# 145
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Wait
Continuation
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Wait
Bridgeport OP# 146
First Piece Inspection
Wait
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Wait
Bridgeport OP# 147
First Piece Inspection
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Move
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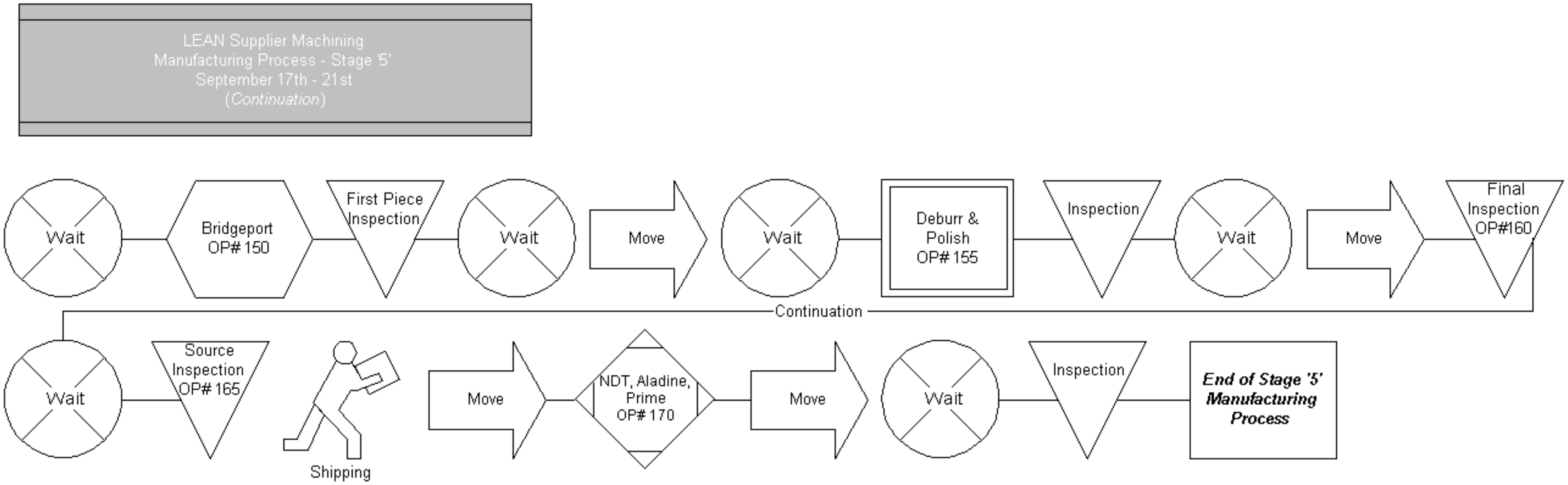
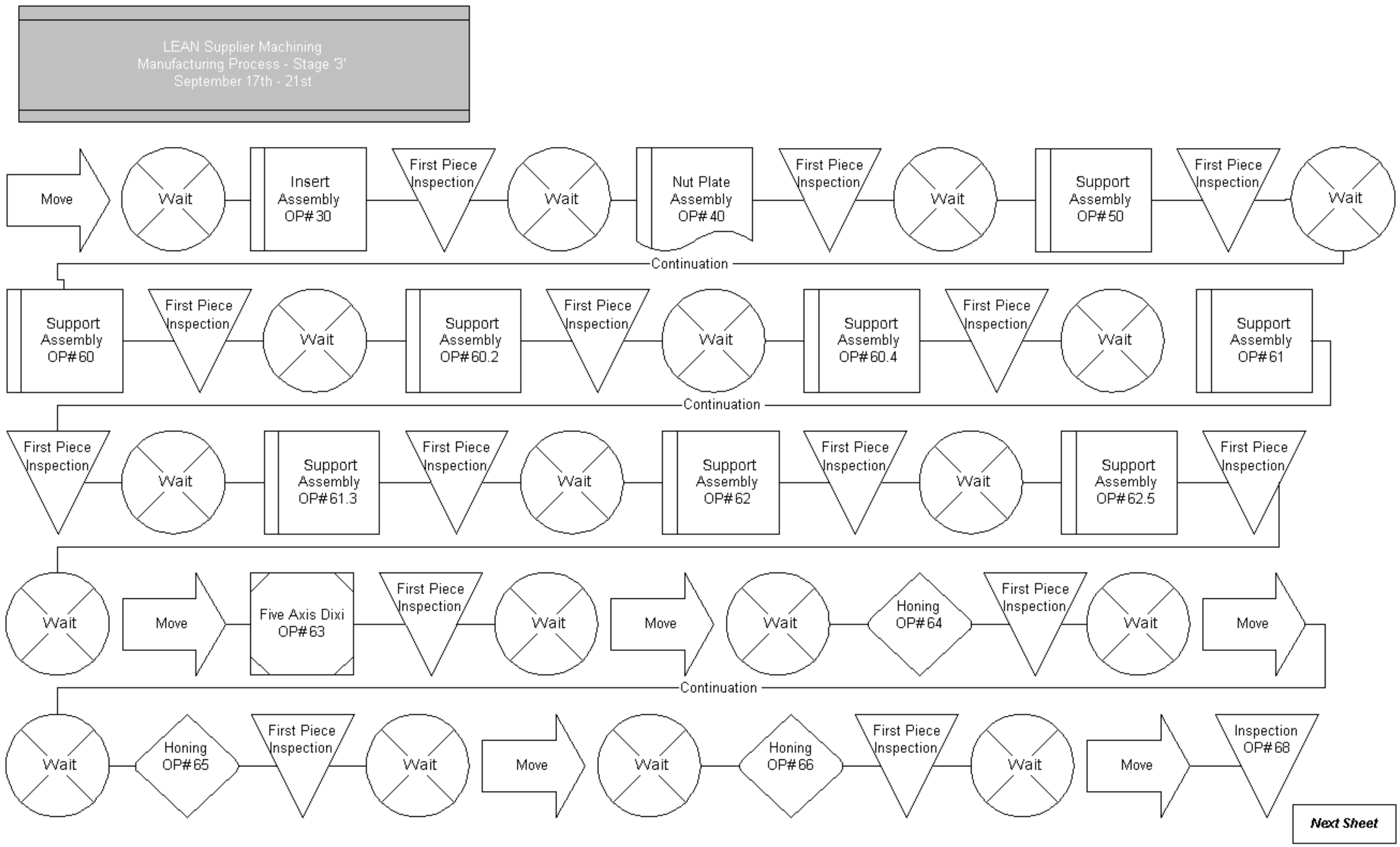
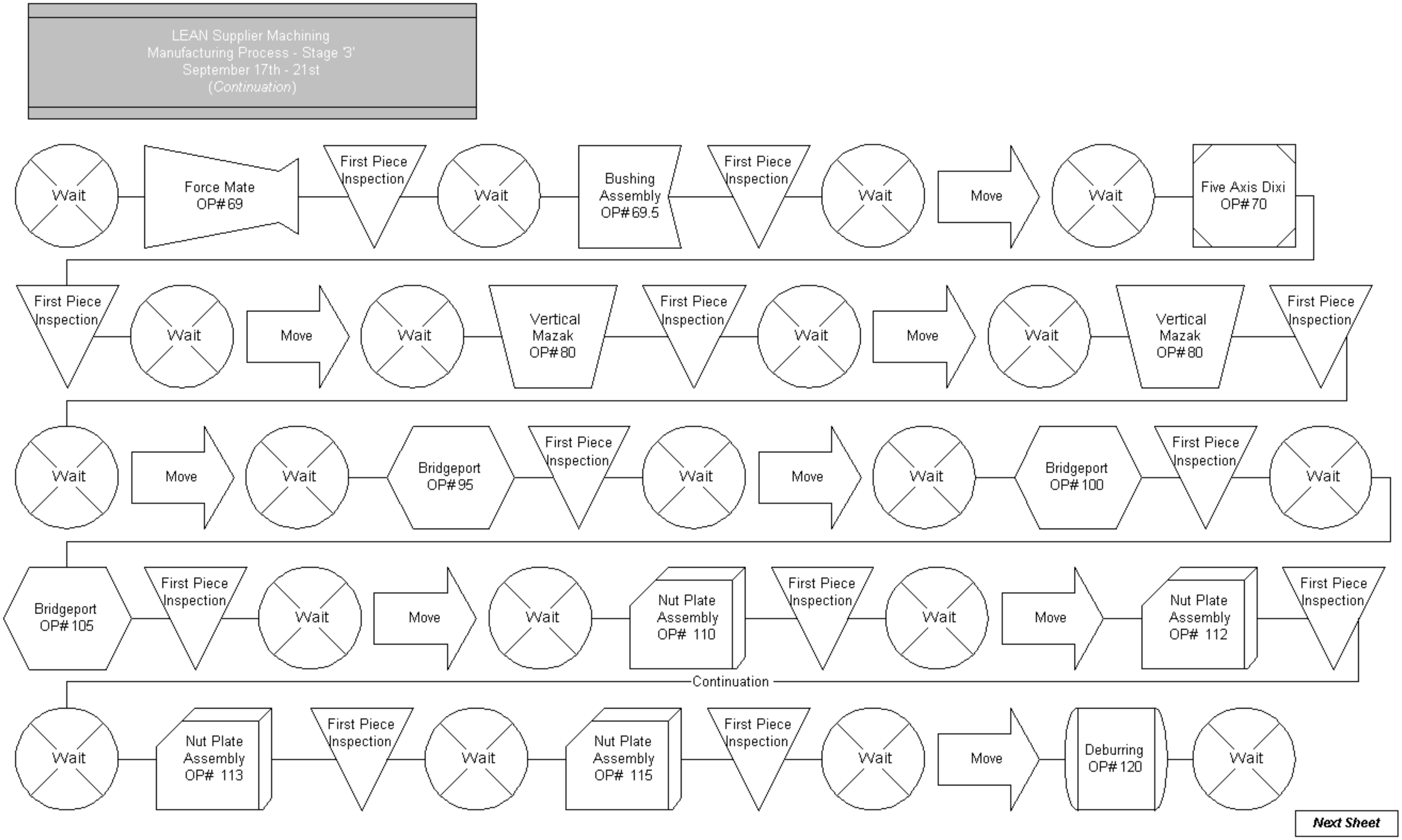
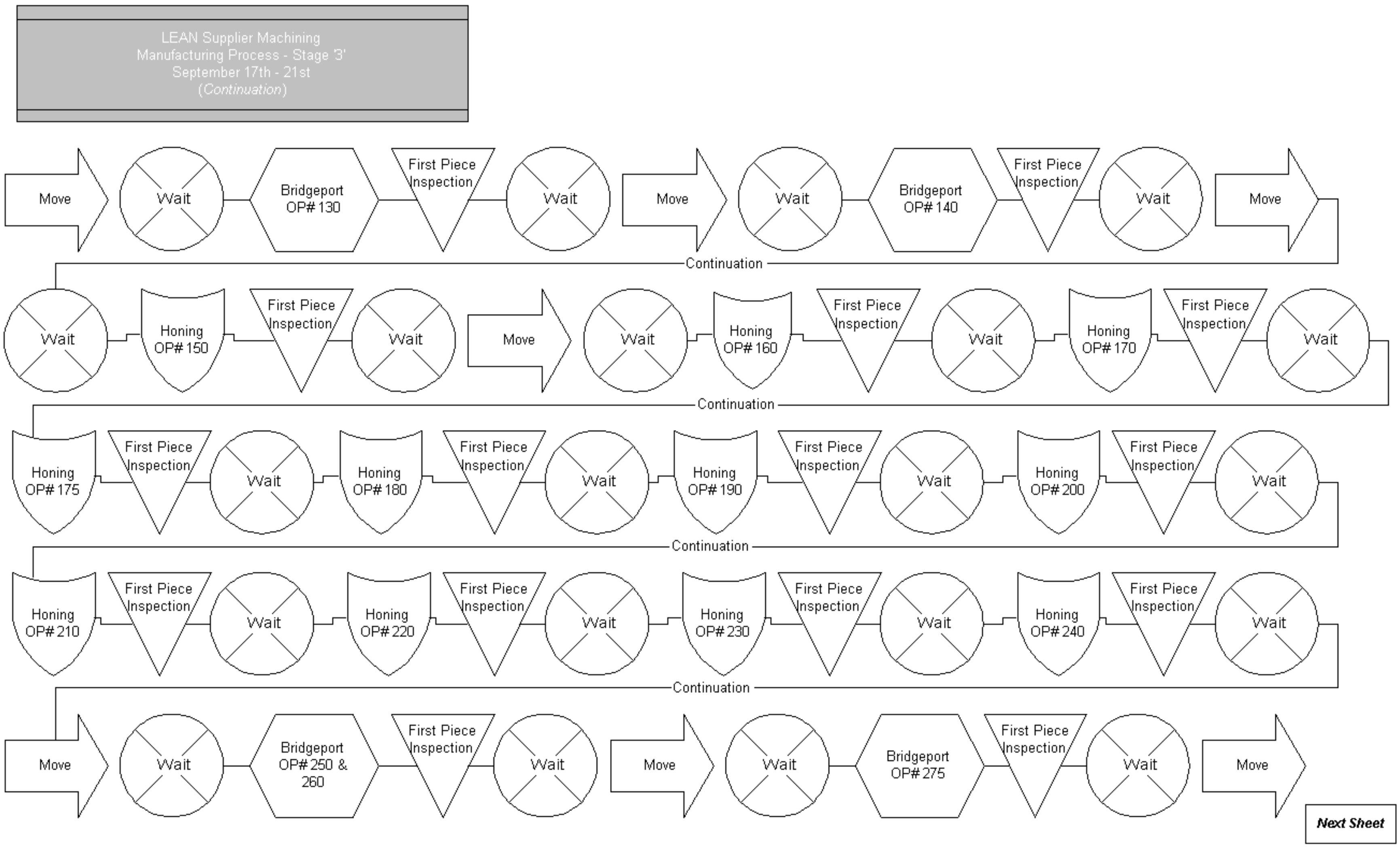
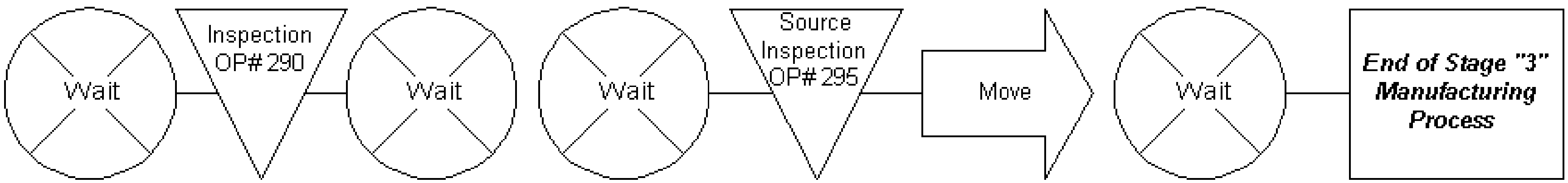

LEAN Supplier Machining
Manufacturing Process - Stage '5'
September 17th - 21st
(*Continuation*)
Wait
Bridgeport OP# 150
First Piece Inspection
Wait
Move
Wait
Deburr & Polish OP# 155
Inspection
Wait
Move
Final Inspection OP#160
Continuation
Wait
Source Inspection OP# 165
Shipping
Move
NDT, Aladine, Prime OP# 170
Move
Wait
Inspection
End of Stage '5' Manufacturing Process

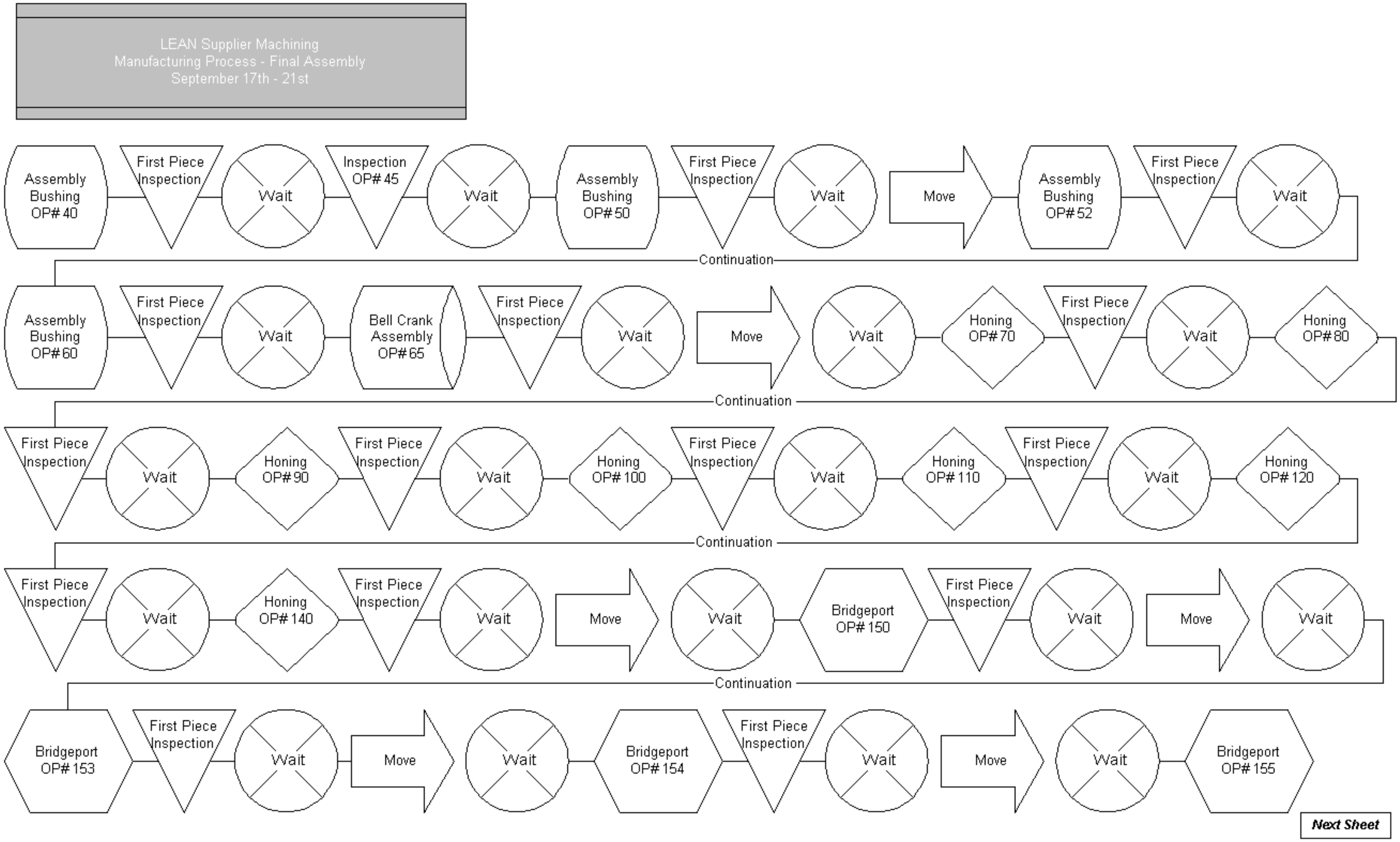

LEAN Supplier Machining
Manufacturing Process - Stage '3'
September 17th - 21st
Move
Wait
Insert Assembly OP# 30
First Piece Inspection
Wait
Nut Plate Assembly OP# 40
First Piece Inspection
Wait
Support Assembly OP# 50
First Piece Inspection
Wait
Continuation
Support Assembly OP# 60
First Piece Inspection
Wait
Support Assembly OP# 60.2
First Piece Inspection
Wait
Support Assembly OP# 60.4
First Piece Inspection
Wait
Support Assembly OP# 61
Continuation
First Piece Inspection
Wait
Support Assembly OP# 61.3
First Piece Inspection
Wait
Support Assembly OP# 62
First Piece Inspection
Wait
Support Assembly OP# 62.5
First Piece Inspection
Wait
Move
Five Axis Dixi OP# 63
First Piece Inspection
Wait
Move
Wait
Honing OP# 64
First Piece Inspection
Wait
Move
Continuation
Wait
Honing OP# 65
First Piece Inspection
Wait
Move
Wait
Honing OP# 66
First Piece Inspection
Wait
Move
Inspection OP# 68
Next Sheet

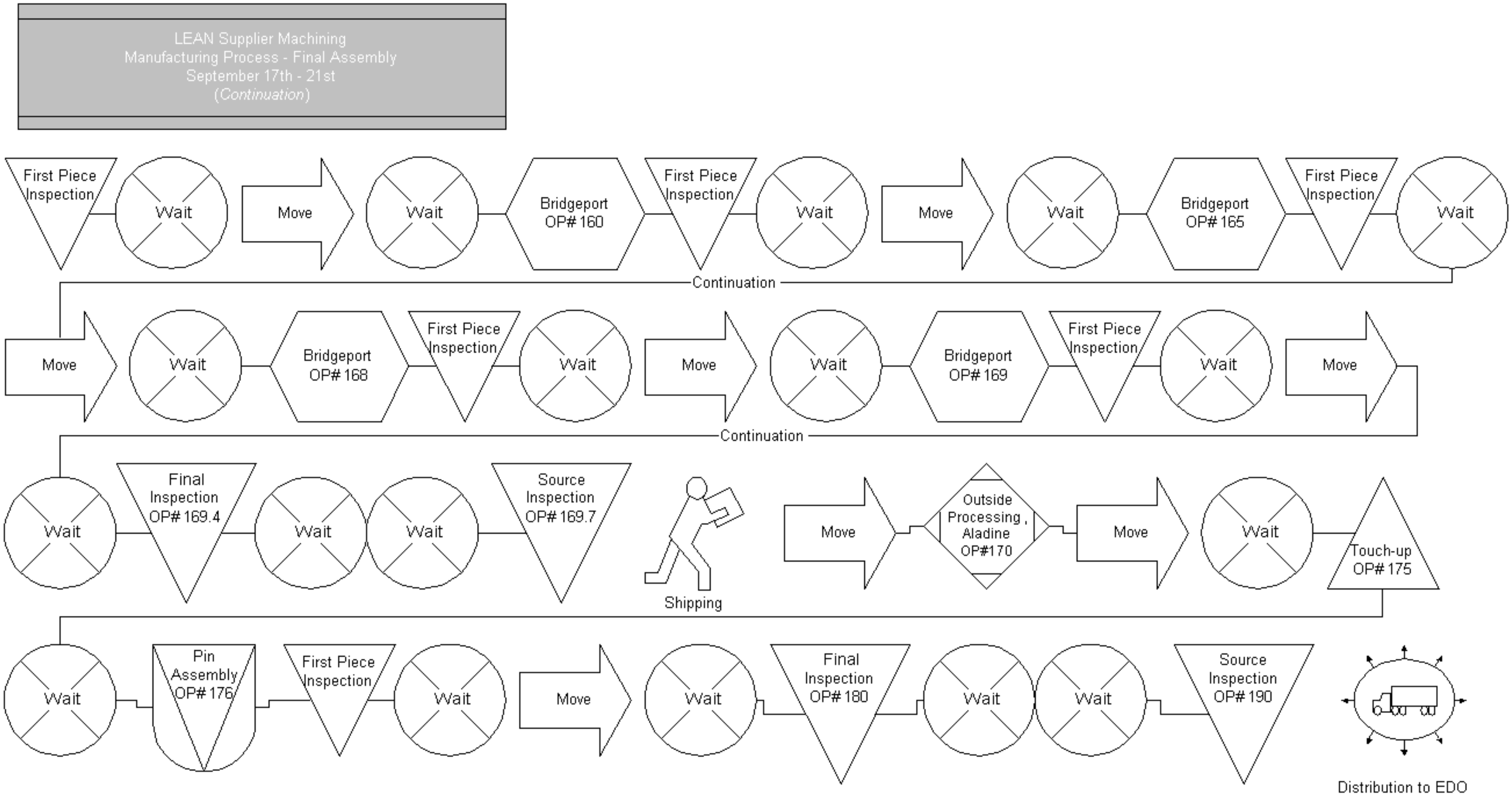

LEAN Supplier Machining
Manufacturing Process - Stage '3'
September 17th - 21st
(Continuation)
Wait
Force Mate OP# 69
First Piece Inspection
Wait
Bushing Assembly OP# 69.5
First Piece Inspection
Wait
Move
Wait
Five Axis Dixi OP# 70
First Piece Inspection
Wait
Move
Wait
Vertical Mazak OP# 80
First Piece Inspection
Wait
Move
Wait
Vertical Mazak OP# 80
First Piece Inspection
Wait
Move
Wait
Bridgeport OP# 95
First Piece Inspection
Wait
Move
Wait
Bridgeport OP# 100
First Piece Inspection
Wait
Bridgeport OP# 105
First Piece Inspection
Wait
Move
Wait
Nut Plate Assembly OP# 110
First Piece Inspection
Wait
Move
Nut Plate Assembly OP# 112
First Piece Inspection
Continuation
Wait
Nut Plate Assembly OP# 113
First Piece Inspection
Wait
Nut Plate Assembly OP# 115
First Piece Inspection
Wait
Move
Deburring OP# 120
Wait
Next Sheet


LEAN Supplier Machining
Manufacturing Process - Stage '3'
September 17th - 21st
(Continuation)
Move
Wait
Bridgeport OP# 130
First Piece Inspection
Wait
Move
Wait
Bridgeport OP# 140
First Piece Inspection
Wait
Move
Continuation
Wait
Honing OP# 150
First Piece Inspection
Wait
Move
Wait
Honing OP# 160
First Piece Inspection
Wait
Honing OP# 170
First Piece Inspection
Wait
Continuation
Honing OP# 175
First Piece Inspection
Wait
Honing OP# 180
First Piece Inspection
Wait
Honing OP# 190
First Piece Inspection
Wait
Honing OP# 200
First Piece Inspection
Wait
Continuation
Honing OP# 210
First Piece Inspection
Wait
Honing OP# 220
First Piece Inspection
Wait
Honing OP# 230
First Piece Inspection
Wait
Honing OP# 240
First Piece Inspection
Wait
Continuation
Move
Wait
Bridgeport OP# 250 & 260
First Piece Inspection
Wait
Move
Wait
Bridgeport OP# 275
First Piece Inspection
Wait
Move
Next Sheet

LEAN Supplier Machining
Manufacturing Process - Stage '3'
September 17th - 21st
(*Continuation*)




LEAN Supplier Machining
Manufacturing Process - Final Assembly
September 17th - 21st
Assembly Bushing OP# 40
First Piece Inspection
Wait
Inspection OP# 45
Wait
Assembly Bushing OP# 50
First Piece Inspection
Wait
Move
Assembly Bushing OP# 52
First Piece Inspection
Wait
Continuation
Assembly Bushing OP# 60
First Piece Inspection
Wait
Bell Crank Assembly OP# 65
First Piece Inspection
Wait
Move
Wait
Honing OP# 70
First Piece Inspection
Wait
Honing OP# 80
Continuation
First Piece Inspection
Wait
Honing OP# 90
First Piece Inspection
Wait
Honing OP# 100
First Piece Inspection
Wait
Honing OP# 110
First Piece Inspection
Wait
Honing OP# 120
Continuation
First Piece Inspection
Wait
Honing OP# 140
First Piece Inspection
Wait
Move
Wait
Bridgeport OP# 150
First Piece Inspection
Wait
Move
Wait
Continuation
Bridgeport OP# 153
First Piece Inspection
Wait
Move
Wait
Bridgeport OP# 154
First Piece Inspection
Wait
Move
Wait
Bridgeport OP# 155
Next Sheet


LEAN Supplier Machining
Manufacturing Process - Final Assembly
September 17th - 21st
(*Continuation*)
First Piece Inspection
Wait
Move
Wait
Bridgeport OP# 160
First Piece Inspection
Wait
Move
Wait
Bridgeport OP# 165
First Piece Inspection
Wait
Continuation
Move
Wait
Bridgeport OP# 168
First Piece Inspection
Wait
Move
Wait
Bridgeport OP# 169
First Piece Inspection
Wait
Move
Continuation
Wait
Final Inspection OP# 169.4
Wait
Wait
Source Inspection OP# 169.7
Shipping
Move
Outside Processing , Aladine OP#170
Move
Wait
Touch-up OP# 175
Wait
Pin Assembly OP# 176
First Piece Inspection
Wait
Move
Wait
Final Inspection OP# 180
Wait
Wait
Source Inspection OP# 190
Distribution to EDO

| Lean Supplier<br>Value Added Process Chart<br>Stage 5 | | | | |
|---|---|---|---|---|
| **Manufacturing Process** | **Process Time** | **Value Added** | **Required Waste** | **Pure Waste** |
| Receipt of Material | | | | |
| Wait | 24 | | | 24 |
| Inspect | 30 | | 30 | |
| Wait | 720 | | | 720 |
| Receive and QC | 15 | | 15 | |
| Wait | 180 | | | 180 |
| Move | 5 | | | 5 |
| Wait | 360 | | | 360 |
| Vertical Mazak OP# 10 | 60 | 60 | | |
| Set-up | 285 | | 285 | |
| 1st Piece Inspection | 30 | | 30 | |
| Wait | 1020 | | | 1020 |
| Move | 5 | | | 5 |
| Wait | 360 | | | 360 |
| Horizontal Mazak OP# 20 | 141 | 141 | | |
| Set-up | 300 | | 300 | |
| 1st Piece Inspection | 30 | | 30 | |
| Wait | 2400 | | | 2400 |
| Move | 5 | | | 5 |
| Wait | 300 | | | 300 |
| Shipping | 30 | | 30 | |
| Move | 20 | | | 20 |
| Heat Treat OP# 25 | 3600 | 3600 | | |
| Move | 20 | | | 20 |
| Wait | 60 | | | 60 |
| Inspect OP#27 | 30 | | 30 | |
| Wait | 360 | | | 360 |
| Move | 5 | | | 5 |
| Re-Prep Vertical Masak OP#30 | 45 | 45 | | |
| Set-up | 69 | | 69 | |
| Inspect | 30 | | 30 | |
| Wait | 768 | | | 768 |
| Move | 5 | | | 5 |
| Wait | 360 | | | 360 |
| Five Axis Dixie OP# 40 | 840 | 840 | | |
| Set-up | 360 | | 360 | |
| Inspect | 30 | | 30 | |
| Wait | 14280 | | | 14280 |
| Move | 5 | | | 5 |
| Wait | 360 | | | 360 |
| Horizontal Masak OP# 50 | 540 | 540 | | |
| Set-up | 180 | | 180 | |
| Inspect | 30 | | 30 | |
| Wait | 9120 | | | 9120 |
| Move | 5 | | | 5 |
| Wait | 360 | | | 360 |
| Vertical Masak OP#60 | 60 | 60 | | |
| Set-up | 240 | | 240 | |
| Inspect | 30 | | 30 | |
| Wait | 1020 | | | 1020 |

| Lean Supplier<br>Value Added Process Chart<br>Stage 5 | | | | |
|---|---|---|---|---|
| **Manufacturing Process** | **Process Time** | **Value Added** | **Required Waste** | **Pure Waste** |
| Move | 5 | | | 5 |
| Wait | 360 | | | 360 |
| Bridgeport OP#70 | 60 | 60 | | |
| Set-up | 30 | | 30 | |
| Inspect | 10 | | 10 | |
| Wait | 1020 | | | 1020 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 71 | 45 | 45 | | |
| Set-up | 45 | | 45 | |
| Inspect | 10 | | 10 | |
| Wait | 768 | | | 768 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 72 | 90 | 90 | | |
| Set-up | 45 | | 45 | |
| Inspect | 10 | | 10 | |
| Wait | 1530 | | | 1530 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP#73 | 90 | 90 | | |
| Set-up | 45 | | 45 | |
| Inspect | 10 | | 10 | |
| Wait | 1530 | | | 1530 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 80 | 30 | 30 | | |
| Set-up | 90 | | 90 | |
| Inspect | 10 | | 10 | |
| Wait | 510 | | | 510 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 90 | 45 | 45 | | |
| Set-up | 90 | | 90 | |
| Inspect | 10 | | 10 | |
| Wait | 768 | | | 768 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 100 | 21 | 21 | | |
| Set-up | 60 | | 60 | |
| Inspect | 10 | | 10 | |
| Wait | 360 | | | 360 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 105 | 45 | 45 | | |
| Set-up | 60 | | 60 | |
| Inspect | 10 | | 10 | |
| Wait | 768 | | | 768 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 110 | 30 | 30 | | |
| Set-up | 60 | | 60 | |

| Lean Supplier<br>Value Added Process Chart<br>Stage 5 | | | | |
|---|---|---|---|---|
| **Manufacturing Process** | **Process Time** | **Value Added** | **Required Waste** | **Pure Waste** |
| Inspect | 10 | | 10 | |
| Wait | 510 | | | 510 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 120 | 30 | 30 | | |
| Set-up | 90 | | 90 | |
| Inspect | 10 | | 10 | |
| Wait | 510 | | | 510 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 125 | 90 | 90 | | |
| Set-up | 90 | | 90 | |
| Inspect | 10 | | 10 | |
| Wait | 1530 | | | 1530 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 127 | 21 | 21 | | |
| Set-up | 0 | | 0 | |
| Inspect | 10 | | 10 | |
| Wait | 360 | | | 360 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 130 | 21 | 21 | | |
| Set-up | 15 | | 15 | |
| Inspect | 10 | | 10 | |
| Wait | 360 | | | 360 |
| Move | 1 | | | 10 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 139 | 21 | 21 | | |
| Set-up | 45 | | 45 | |
| Inspect | 10 | | 10 | |
| Wait | 360 | | | 360 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 140 | 21 | 21 | | |
| Set-up | 45 | | 45 | |
| Inspect | 10 | | 10 | |
| Wait | 360 | | | 360 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 141 | 30 | 30 | | |
| Set-up | 45 | | 45 | |
| Inspect | 10 | | 10 | |
| Wait | 510 | | | 510 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 142 | 30 | 30 | | |
| Set-up | 45 | | 45 | |
| Inspect | 10 | | 10 | |
| Wait | 510 | | | 510 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |

| Lean Supplier<br>Value Added Process Chart<br>Stage 5 | | | | |
|---|---|---|---|---|
| **Manufacturing Process** | **Process Time** | **Value Added** | **Required Waste** | **Pure Waste** |
| Bridgeport OP# 143 | 30 | 30 | | |
| Set-up | 0 | | 0 | |
| Inspect | 10 | | 10 | |
| Wait | 510 | | | 510 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 144 | 21 | 21 | | |
| Set-up | 45 | | 45 | |
| Inspect | 10 | | 10 | |
| Wait | 360 | | | 360 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 145 | 21 | 21 | | |
| Set-up | 0 | | 0 | |
| Inspect | 10 | | 10 | |
| Wait | 360 | | | 360 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 146 | 21 | 21 | | |
| Set-up | 45 | | 45 | |
| Inspect | 10 | | 10 | |
| Wait | 360 | | | 360 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 147 | 15 | 15 | | |
| Set-up | 45 | | 45 | |
| Inspect | 10 | | 10 | |
| Wait | 255 | | | 255 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 148 | 15 | 15 | | |
| Set-up | 45 | | 45 | |
| Inspect | 10 | | 10 | |
| Wait | 255 | | | 255 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 149 | 21 | 21 | | |
| Set-up | 45 | | 45 | |
| Inspect | 10 | | 10 | |
| Wait | 360 | | | 360 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 150 | 15 | 15 | | |
| Set-up | 30 | | 30 | |
| Inspect | 10 | | 10 | |
| Wait | 255 | | | 255 |
| Move | 5 | | | 5 |
| Wait | 2880 | | | 2880 |
| Deburr & Polish OP# 155 | 600 | | 600 | |
| Inspect | 15 | | 15 | |
| Wait | 10200 | | | 10200 |
| Move | 5 | | | 5 |

| Lean Supplier<br>Value Added Process Chart<br>Stage 5 | | | | |
|---|---|---|---|---|
| **Manufacturing Process** | **Process Time** | **Value Added** | **Required Waste** | **Pure Waste** |
| Final Inspection OP# 160 | 600 | | 600 | |
| Wait | 1440 | | | 1440 |
| Source Inspection OP# 165 | 480 | | 480 | |
| Shipping | 30 | | 30 | |
| Move | 20 | | 20 | |
| NDT/Aladine/Prime OP# 170 | 15000 | 15000 | | |
| Move | 20 | | | 20 |
| Wait | 60 | | | 60 |
| Inspect | 15 | | | 15 |
| **Total Column Times** | **89,594** | **21,165** | **4,869** | **63,569** |
| **Time Expressed in Percentage** | | **24%** | **5%** | **71%** |

**Lean Supplier**
**Value Added Process Chart**
**Stage 3**

| Manufacturing Process | Process Time | Value Added | Required Waste | Pure Waste |
|---|---|---|---|---|
| Move | 5 | | | 5 |
| Wait | 60 | | | 60 |
| Insert Assembly OP# 30 | 45 | 45 | | |
| Set-up | 30 | | 30 | |
| Inspect | 10 | | 10 | |
| Wait | 765 | | | 765 |
| Nut Plate Assembly OP# 40 | 60 | 60 | | |
| Set-up | 30 | | 30 | |
| Inspect | 10 | | 10 | |
| Wait | 1020 | | | 1020 |
| Support Assembly OP# 50 | 15 | 15 | | |
| Set-up | 15 | | 15 | |
| Inspect | 10 | | 10 | |
| Wait | 255 | | | 255 |
| Support Assembly OP# 60 | 15 | 15 | | |
| Set-up | 60 | | 60 | |
| Inspect | 5 | | 5 | |
| Wait | 168 | | | 168 |
| Support Assembly OP# 60.2 | 10 | 10 | | |
| Set-up | 30 | | 30 | |
| Inspect | 5 | | 5 | |
| Wait | 168 | | | 168 |
| Support Assembly OP# 60.4 | 10 | 10 | | |
| Set-up | 30 | | 30 | |
| Inspect | 5 | | 5 | |
| Wait | 168 | | | 168 |
| Support Assembly OP# 61 | 10 | 10 | | |
| Set-up | 30 | | 30 | |
| Inspect | 5 | | 5 | |
| Wait | 168 | | | 168 |
| Support Assembly OP# 61.3 | 60 | 60 | | |
| Set-up | 60 | | 60 | |
| Inspect | 5 | | 5 | |
| Wait | 1020 | | | 1020 |
| Support Assembly OP# 62 | 150 | 150 | | |
| Set-up | 60 | | 60 | |
| Inspect | 5 | | 5 | |
| Wait | 2550 | | | 2550 |
| Support Assembly OP# 62.5 | 20 | 20 | | |
| Set-up | 30 | | 30 | |
| Inspect | 5 | | 5 | |
| Wait | 336 | | | 336 |
| Move | 5 | | 5 | |
| Five Axis Dixie OP# 63 | 210 | 210 | | |
| Set-up | 150 | | 150 | |
| Inspect | 30 | | 30 | |
| Wait | 3600 | | | 3600 |
| Move | 5 | | | 5 |
| Wait | 480 | | | 480 |
| Honing OP# 64 | 6 | 6 | | |
| Set-up | 60 | | 60 | |

| Lean Supplier<br>Value Added Process Chart<br>Stage 3 | | | | |
|---|---|---|---|---|
| **Manufacturing Process** | **Process Time** | **Value Added** | **Required Waste** | **Pure Waste** |
| Inspect | 5 | | 5 | |
| Wait | 102 | | | 102 |
| Move | 1 | | | 1 |
| Wait | 30 | | | 30 |
| Honing OP# 65 | 6 | 6 | | |
| Set-up | 60 | | 60 | |
| Inspect | 5 | | 5 | |
| Wait | 102 | | | 102 |
| Move | 1 | | | 1 |
| Wait | 30 | | | 30 |
| Honing OP# 66 | 6 | 6 | | |
| Set-up | 60 | | 60 | |
| Inspect | 5 | | 5 | |
| Wait | 102 | | | 102 |
| Move | 1 | | | 1 |
| Inspect OP# 68 | 30 | 30 | | |
| Wait | 510 | | | 510 |
| Force Mate OP# 69 | 30 | 30 | | |
| Set-up | 30 | | 30 | |
| Inspect | 10 | | 10 | |
| Wait | 510 | | | 510 |
| Bushing Assembly OP# 69.5 | 30 | 30 | | |
| Set-up | 0 | | 0 | |
| Inspect | 10 | | 10 | |
| Wait | 990 | | | 990 |
| Move | 5 | | | 5 |
| Wait | 360 | | | 360 |
| Five Axis Dixie OP# 70 | 240 | 240 | | |
| Set-up | 60 | | 60 | |
| Inspect | 30 | | 30 | |
| Wait | 4080 | | | 4080 |
| Move | 5 | | | 5 |
| Wait | 360 | | | 360 |
| Vertical Masak OP# 80 | 60 | 60 | | |
| Set-up | 120 | | 120 | |
| Inspect | 30 | | 30 | |
| Wait | 1020 | | | 1020 |
| Move | 5 | | | 5 |
| Wait | 360 | | | 360 |
| Vertical Masak OP# 90 | 30 | 30 | | |
| Set-up | 0 | | 0 | |
| Inspect | 30 | | 30 | |
| Wait | 510 | | | 510 |
| Move | 5 | | | 5 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 95 | 30 | 30 | | |
| Set-up | 15 | | 15 | |
| Inspect | 10 | | 10 | |
| Wait | 510 | | | 510 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 100 | 120 | 120 | | |

| Lean Supplier<br>Value Added Process Chart<br>Stage 3 | | | | |
|---|---|---|---|---|
| **Manufacturing Process** | **Process Time** | **Value Added** | **Required Waste** | **Pure Waste** |
| Set-up | 30 | | 30 | |
| Inspect | 10 | | 10 | |
| Wait | 2040 | | | 2040 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 105 | 45 | 45 | | |
| Set-up | 15 | | 15 | |
| Inspect | 10 | | 10 | |
| Wait | 765 | | | 765 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Nut Plate Assembly OP# 110 | 20 | 20 | | |
| Set-up | 15 | | 15 | |
| Inspect | 5 | | 5 | |
| Wait | 340 | | | 340 |
| Move | 5 | | | 5 |
| Nut Plate Assembly OP# 112 | 208 | 208 | | |
| Set-up | 60 | | 60 | |
| Inspect | 10 | | 10 | |
| Wait | 3540 | | | 3540 |
| Nut Plate Assembly OP# 113 | 264 | 264 | | |
| Set-up | 30 | | 30 | |
| Inspect | 10 | | 10 | |
| Wait | 4488 | | | 4488 |
| Nut Plate Assembly OP# 115 | 60 | 60 | | |
| Set-up | 10 | | 10 | |
| Inspect | 10 | | 10 | |
| Wait | 1020 | | | 1020 |
| Move | 5 | | | 5 |
| Deburr OP# 120 | 180 | | 180 | |
| Wait | 3060 | | | 3060 |
| Move | 5 | | | 5 |
| Wait | 60 | | | 60 |
| Bridge[port OP# 130 | 30 | 30 | | |
| Set-up | 45 | | 45 | |
| Inspect | 10 | | 10 | |
| Wait | 510 | | | 510 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 140 | 30 | 30 | | |
| Set-up | 45 | | 45 | |
| Inspect | 10 | | 10 | |
| Wait | 510 | | | 510 |
| Move | 1 | | | 1 |
| Wait | 30 | | | 30 |
| Honing OP# 150 | 30 | 30 | | |
| Set-up | 45 | | 45 | |
| Inspect | 5 | | 5 | |
| Wait | 510 | | | 510 |
| Move | 5 | | | 5 |
| Wait | 30 | | | 30 |
| Honing OP# 160 | 17 | 17 | | |

| Lean Supplier<br>Value Added Process Chart<br>Stage 3 | | | | |
|---|---|---|---|---|
| **Manufacturing Process** | **Process Time** | **Value Added** | **Required Waste** | **Pure Waste** |
| Set-up | 66 | | 66 | |
| Inspect | 5 | | 5 | |
| Wait | 286 | | | 286 |
| Honing OP# 170 | 13 | 13 | | |
| Set-up | 45 | | 45 | |
| Inspect | 5 | | 5 | |
| Wait | 224 | | | 224 |
| Honing OP# 175 | 60 | 60 | | |
| Set-up | 80 | | 80 | |
| Inspect | 5 | | 5 | |
| Wait | 602 | | | 602 |
| Honing OP# 180 | 53 | 53 | | |
| Set-up | 120 | | 120 | |
| Inspect | 5 | | 5 | |
| Wait | 541 | | | 541 |
| Honing OP# 190 | 43 | 43 | | |
| Set-up | 15 | | 15 | |
| Inspect | 5 | | 5 | |
| Wait | 439 | | | 439 |
| Honing OP# 200 | 16 | 16 | | |
| Set-up | 15 | | 15 | |
| Inspect | 5 | | 5 | |
| Wait | 265 | | | 265 |
| Honing OP# 210 | 13 | 13 | | |
| Set-up | 46 | | 46 | |
| Inspect | 5 | | 5 | |
| Wait | 214 | | | 214 |
| Honing OP# 220 | 70 | 70 | | |
| Set-up | 30 | | 30 | |
| inspect | 5 | | 5 | |
| Wait | 1182 | | | 1182 |
| Honing OP# 230 | 19 | 19 | | |
| Set-up | 0 | | 0 | |
| Inspect | 5 | | 5 | |
| Wait | 324 | | | 324 |
| Honing OP# 240 | 26 | 26 | | |
| Set-up | 165 | | 165 | |
| Inspect | 5 | | 5 | |
| Wait | 450 | | | 450 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 250 & 260 | 84 | 84 | | |
| Set-up | 90 | | 90 | |
| Inspect | 10 | | 10 | |
| Wait | 1428 | | | 1428 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 275 | 45 | 45 | | |
| Set-up | 90 | | 90 | |
| Inspect | 10 | | 10 | |
| Wait | 765 | | | 765 |
| Move | 1 | | | 1 |

| Lean Supplier<br>Value Added Process Chart<br>Stage 3 | | | | |
|---|---|---|---|---|
| **Manufacturing Process** | **Process Time** | **Value Added** | **Required Waste** | **Pure Waste** |
| Wait | 120 | | | 120 |
| Inspect OP# 290 | 60 | | 60 | |
| Wait | 1020 | | | 1020 |
| Wait | 1440 | | | 1440 |
| Source Inspect OP# 295 | 480 | | 480 | |
| Move | 20 | | | 20 |
| Wait | 60 | | | 60 |
| **Total Column Times** | **52,524** | **2,339** | **3,092** | **47,093** |
| **Time Expressed in Percentage** | | **4%** | **6%** | **90%** |

| Lean Supplier<br>Value Added Process Chart<br>Final Assembly | | | | |
|---|---|---|---|---|
| **Manufacturing Process** | **Process Time** | **Value Added** | **Required Waste** | **Pure Waste** |
| Assembly Bushing OP# 40 | 33 | 33 | | |
| Set-up | 0 | | 0 | |
| Inspect | 20 | | 20 | |
| Wait | 561 | | | 561 |
| Inspection OP# 45 | 33 | 33 | | |
| Set-up | 0 | | 0 | |
| Inspect | 20 | | 20 | |
| Wait | 561 | | | 561 |
| Assembly Bushing OP# 50 | 90 | 90 | | |
| Set-up | 0 | | 0 | |
| Wait | 1530 | | | 1530 |
| Move | 5 | | | 5 |
| Assembly Bushing OP# 52 | 45 | 45 | | |
| Set-up | 30 | | 30 | |
| Inspect | 15 | | 15 | |
| Wait | 765 | | | 765 |
| Assembly Bushing OP# 60 | 45 | 45 | | |
| Set-up | 30 | | 30 | |
| Inspect | 15 | | 15 | |
| Wait | 765 | | | 765 |
| Bell Crank Assembly OP# 65 | 45 | 45 | | |
| Set-up | 15 | | 15 | |
| Inspect | 15 | | 15 | |
| Wait | 765 | | | 765 |
| Move | 1 | | | 1 |
| Wait | 30 | | | 30 |
| Honing OP# 70 | 66 | 66 | | |
| Set-up | 0 | | 0 | |
| Inspect | 5 | | 5 | |
| Wait | 1122 | | | 1122 |
| Honing OP# 80 | 22 | 22 | | |
| Set-up | 0 | | 0 | |
| Inspect | 5 | | 5 | |
| Wait | 367 | | | 367 |
| Honing OP# 90 | 22 | 22 | | |
| Set-up | 0 | | 0 | |
| Inspect | 5 | | 5 | |
| Wait | 367 | | | 367 |
| Honing OP# 100 | 33 | 33 | | |
| Set-up | 0 | | 0 | |
| Inspect | 5 | | 5 | |
| Wait | 561 | | | 561 |
| Honing OP# 110 | 33 | 33 | | |
| Set-up | 0 | | 0 | |
| Inspect | 5 | | 5 | |
| Wait | 561 | | | 561 |
| Honing OP# 120 | 66 | 66 | | |
| Set-up | 0 | | 0 | |

| Lean Supplier<br>Value Added Process Chart<br>Final Assembly | | | | |
|---|---|---|---|---|
| **Manufacturing Process** | **Process Time** | **Value Added** | **Required Waste** | **Pure Waste** |
| Inspect | 5 | | 5 | |
| Wait | 1122 | | | 1122 |
| Honing OP# 140 | 143 | 143 | | |
| Set-up | 0 | | 0 | |
| Inspect | 5 | | 5 | |
| Wait | 41 | | | 41 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 150 | 38 | 38 | | |
| Set-up | 0 | | 0 | |
| Inspect | 10 | | 10 | |
| Wait | 643 | | | 643 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 153 | 20 | 20 | | |
| Set-up | 0 | | 0 | |
| Inspect | 10 | | 10 | |
| Wait | 337 | | | 337 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 154 | 20 | 20 | | |
| Set-up | 0 | | 0 | |
| Inspect | 10 | | 10 | |
| Wait | 337 | | | 337 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 155 | 30 | 30 | | |
| Set-up | 90 | | 90 | |
| Inspect | 10 | | 10 | |
| Wait | 510 | | | 510 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 160 | 15 | 15 | | |
| Set-up | 40 | | 40 | |
| Inspect | 10 | | 10 | |
| Wait | 255 | | | 255 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 165 | 40 | 40 | | |
| Set-up | 78 | | 78 | |
| Inspect | 10 | | 10 | |
| Wait | 673 | | | 673 |
| Move | 1 | | | 1 |
| Wait | 60 | | | 60 |
| Bridgeport OP# 168 | 45 | 45 | | |
| Set-up | 78 | | 78 | |
| Inspect | 10 | | 10 | |
| Wait | 765 | | | 765 |
| Move | 1 | | | |

| Lean Supplier<br>Value Added Process Chart<br>Final Assembly | | | | |
|---|---|---|---|---|
| **Manufacturing Process** | **Process Time** | **Value Added** | **Required Waste** | **Pure Waste** |
| Wait | 60 | | | |
| Bridgeport OP# 169 | 10 | 10 | | |
| Set-up | 0 | | 0 | |
| Inspect | 10 | | 10 | |
| Wait | 163 | | | 163 |
| Move | 1 | | | 1 |
| Wait | 30 | | | 30 |
| Final Inspection OP# 169.4 | 3240 | 3240 | | |
| Wait | 3060 | | | 3060 |
| Wait | 240 | | | 240 |
| Source Inspection OP# 169.7 | 720 | 720 | | |
| Shipping | 30 | | 30 | |
| Move | 20 | | | 20 |
| Outside Processing ( Alodine) OP# 170 | 2400 | 2400 | | |
| Move | 20 | | | 20 |
| Wait | 60 | | | 60 |
| Touch-up OP# 175 | 60 | | 60 | |
| Wait | 1020 | | | 1020 |
| Pin Assembly OP# 178 | 20 | 20 | | |
| Set-up | 10 | | 10 | |
| Inspect | 10 | | 10 | |
| Wait | 340 | | | 340 |
| Move | 1 | | | 1 |
| Wait | 30 | | | 30 |
| Final Inspection OP# 180 | 60 | | 60 | |
| Wait | 17340 | | | 17340 |
| Wait | 1440 | | | 1440 |
| Source Inspection OP# 190 | 720 | | 720 | |
| **Total Column Times** | **45,622** | **7,274** | **1,451** | **36,836** |
| **Time Expressed in Percentage** | | **16%** | **3%** | **81%** |

| Lean Supplier<br>Spaghetti Diagam<br>( Distance Traveled between Processes)<br>Final Calculations | |
|---|---|
| **Stage 5** | **5070** |
| **Stage 3** | **7710** |
| **Final Assembly** | **1140** |
| **Total Distance in Feet** | **13,920** |
| ***Distance in Miles*** | **2.64** |

| Lean Supplier<br>Spaghetti Diagram<br>( Distance Traveled between Processes)<br>Stage 5 | |
|---|---|
| **Machine Operation** | **Distance Traveled in Feet** |
| Vertical Masak OP# 10 | **Begin** |
| Vertical Masak OP# 15 | 510 |
| Horizontal 4-Axis OP# 20 | 150 |
| Vertical Masak OP# 30 | 85 |
| 5-Axis DIXI OP# 40 | 285 |
| Horizontal 4-Axis OP# 45 | 285 |
| Horizontal 4-Axis OP# 50 | 220 |
| Vertical Masak OP# 60 | 85 |
| Bridgeport OP# 70 | 1240 |
| Bridgeport OP# 71 | 15 |
| Bridgeport OP# 72 | 15 |
| Bridgeport OP# 73 | 15 |
| Bridgeport OP# 80 | 15 |
| Bridgeport OP# 90 | 15 |
| Bridgeport OP# 100 | 15 |
| Bridgeport OP# 105 | 15 |
| Bridgeport OP# 110 | 15 |
| Bridgeport OP# 120 | 15 |
| Bridgeport OP# 125 | 15 |
| Bridgeport OP# 127 | 15 |
| Bridgeport OP# 130 | 15 |
| Bridgeport OP# 131 | 15 |
| Bridgeport OP# 132 | 15 |
| Bridgeport OP# 139 | 15 |
| Bridgeport OP# 140 | 15 |
| Bridgeport OP# 141 | 15 |
| Bridgeport OP# 142 | 15 |
| Bridgeport OP# 143 | 15 |
| Bridgeport OP# 144 | 15 |
| Bridgeport OP# 145 | 15 |
| Bridgeport OP# 146 | 15 |
| Bridgeport OP# 147 | 15 |
| Bridgeport OP# 148 | 15 |
| Bridgeport OP# 149 | 15 |
| Bridgeport OP# 150 | 15 |
| Deburr OP# 155 | 810 |
| Final Inspection OP# 160 | 100 |
| Source Inspection OP# 165 | 910 |
| **Total (feet)** | **5070** |

| Lean Supplier<br>Spaghetti Diagram<br>( Distance Traveled between Processes)<br>Stage 3 | |
|---|---|
| **Machine Operation** | **Distance Traveled in Feet** |
| Source Inspection OP# 165 | **Begin** |
| Assembly OP# 30 | 200 |
| Assembly OP# 40 | 35 |
| Assembly OP# 50 | 35 |
| Assembly OP# 60 | 35 |
| 5-Axis DIXI OP# 63 | 810 |
| Honing OP# 64 | 930 |
| Honing OP# 65 | 0 |
| Honing OP# 66 | 0 |
| Honing OP# 67 | 0 |
| Inspection OP# 68 | 240 |
| Assembly OP# 69 | 260 |
| Assembly OP# 69.5 | 35 |
| 5-Axis DIXI OP# 70 | 810 |
| Masak OP# 80 | 285 |
| Masak OP# 90 | 0 |
| Bridgeport OP# 95 | 1240 |
| Bridgeport OP# 100 | 15 |
| Bridgeport OP# 105 | 15 |
| Assembly OP# 110 | 80 |
| Deburring OP# 120 | 820 |
| Bridgeport OP# 130 | 910 |
| Bridgeport OP# 140 | 15 |
| Bridgeport OP# 150 | 15 |
| Assembly OP# 155 | 80 |
| Honing OP# 160 | 65 |
| Honing OP# 170 | 0 |
| Honing OP# 175 | 0 |
| Honing OP# 180 | 0 |
| Bridgeport (Lapping) OP# 190 | 50 |
| Honing OP# 200 | 0 |
| Honing OP# 210 | 0 |
| Honing OP# 220 | 230 |
| Honing OP# 230 | 220 |
| Honing OP# 240 | 0 |
| Bridgeport OP# 250 & 260 | 65 |
| Bridgeport OP# 275 | 15 |
| Shipping | 200 |
| **Total (feet)** | **7710** |

| Lean Supplier<br>Spaghetti Diagram<br>( Distance Traveled between Processes)<br>Final Assembly | |
|---|---|
| **Machine Operation** | **Distance Traveled in Feet** |
| Receiveing | **Begin** |
| Assembly OP# 40 | 200 |
| Assembly OP# 45 | 0 |
| Assembly OP# 50 | 0 |
| Assembly OP# 60 | 0 |
| Assembly OP# 65 | 0 |
| Honing OP# 70 | 70 |
| Honing OP# 80 | 70 |
| Honing OP# 90 | 0 |
| Honing OP# 100 | 0 |
| Honing OP# 110 | 70 |
| Honing OP# 120 | 0 |
| Honing OP# 130 | 0 |
| Honing OP# 140 | 0 |
| Bridgeport OP# 150 | 50 |
| Bridgeport OP# 153 | 0 |
| Bridgeport OP# 154 | 0 |
| Bridgeport OP# 155 | 0 |
| Bridgeport OP# 160 | 0 |
| Bridgeport OP# 165 | 0 |
| Bridgeport OP# 168 | 0 |
| Bridgeport OP# 169 | 0 |
| Outsourcing OP# 170 | 200 |
| Bench OP# 175 | 240 |
| Inspection OP# 180 | 240 |
| OP# 190 | |
| **Total** | **1140** |

The VAST team represented the Lean technique of value stream mapping using VISIO software to help the supplier identify their manufacturing processes for the F/A-22 Upper Beam. Data charts containing the raw calculations are also included.

**Lean Supplier**
**Calculation of Process Times for Upper Beam**

| | Process Time | Value Added | Required Waste | Pure Waste |
|---|---|---|---|---|
| Upper Beam | 27,498 | 8,590 | 2,331 | 16,534 |
| Total Process Times (Minutes) | 27,498 | 8,590 | 2,331 | 16,534 |

** all figures are in minutes*

| | |
|---|---|
| Value Added as a percentage of Total Process Time | 31% |
| Required Waste as a percentage of Total Process Time | 8% |
| Pure Waste as a percentage of Total Process Time | 60% |

| Lean Supplier Upper Beam | | | | |
|---|---|---|---|---|
| **Process Step** | **Total Process Time** | **Value Added** | **Non-Value Added** | **Waste** |
| Receive Material | | | | |
| Inspection | 10 | | 10 | |
| Move | 15 | | | 15 |
| Wait | 935 | | | 935 |
| OP 5 - Mazak | | | | |
| S/U | 150 | | 150 | |
| C/T | 85 | 85 | | |
| Wait | 5 | | | 5 |
| Move | 15 | | | 15 |
| Wait | 300 | | | 300 |
| OP 7 - Process (Heat Treat) | 2400 | 2400 | | |
| Wait | 33 | | | 5 |
| OP 9 - Inspection | 3 | | 3 | |
| Move | 15 | | | 15 |
| Wait | 1089 | | | 1089 |
| OP 10 - Vertical Mazak | | | | |
| S/U | 420 | | 420 | |
| C/T | 99 | 99 | | |
| Move | 1 | | | 1 |
| Wait | 1980 | | | 1980 |
| OP 20 - Horizontal Mazak | | | | |
| S/U | 330 | | 330 | |
| C/T | 180 | 180 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 1 | | | 1 |
| Wait | 660 | | | 660 |
| OP 40 - Vertical Mazak | | | | |
| S/U | 180 | | 180 | |
| C/T | 60 | 60 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 1 | | | 1 |
| Wait | 3300 | | | 3300 |
| OP 50 - Horizontal Mazak | | | | |
| S/U | 120 | | 120 | |
| C/T | 300 | 300 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 1 | | | 1 |
| Wait | 770 | | | 770 |
| OP 60 - Vertical Mazak | | | | |
| S/U | 120 | | 120 | |
| C/T | 70 | 70 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 1 | | | 1 |
| Wait | 1331 | | | 1331 |
| OP 70 - Horizontal Mazak | | | | |

| Lean Supplier Upper Beam | | | | |
|---|---|---|---|---|
| **Process Step** | **Total Process Time** | **Value Added** | **Non-Value Added** | **Waste** |
| S/U | 240 | | 240 | |
| C/T | 121 | 121 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 15 | | | 15 |
| Wait | 55 | | | 55 |
| OP 80 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |
| OP 90 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |
| OP 100 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |
| OP 103 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |
| OP 105 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |
| OP 107 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Inspection | 5 | | 5 | |
| Wait | 5 | | | 5 |
| Move | 15 | | | 15 |
| Wait | 495 | | | 495 |
| OP 110 - Bridgeport | | | | |
| S/U | 30 | | 30 | |
| C/T | 45 | 45 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 385 | | | 385 |
| OP 120 - Brdigeport | | | | |
| S/U | 20 | | 20 | |
| C/T | 35 | 35 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |

| Lean Supplier Upper Beam | | | | |
|---|---|---|---|---|
| **Process Step** | **Total Process Time** | **Value Added** | **Non-Value Added** | **Waste** |
| Wait | 165 | | | 165 |
| OP 121 - Bridgeport | | | | |
| S/U | 0 | | 0 | |
| C/T | 15 | 15 | | |
| Inspection | 5 | | 5 | |
| Wait | 220 | | | 220 |
| OP 123 - Bridgeport | | | | |
| S/U | 15 | | 15 | |
| C/T | 20 | 20 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 110 | | | 110 |
| OP 125 - Bridgeport | | | | |
| S/U | 20 | | 20 | |
| C/T | 10 | 10 | | |
| Inspection | 5 | | 5 | |
| Wait | 110 | | | 110 |
| OP 128 - Bridgeport | | | | |
| S/U | 10 | | 10 | |
| C/T | 10 | 10 | | |
| Inspection | 5 | | 5 | |
| Wait | 110 | | | 110 |
| OP 129 - Bridgeport | | | | |
| S/U | 10 | | 10 | |
| C/T | 10 | 10 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 15 | | | 15 |
| Wait | 300 | | | 300 |
| OP 130 - Deburr | | | | |
| C/T | 45 | | 45 | |
| Wait | 5 | | | 5 |
| Move | 15 | | | 15 |
| Wait | 445 | | | 445 |
| OP 140 - Inspection | | | | |
| S/U | 30 | | 30 | |
| C/T | 45 | 45 | | |
| OP 150 - Source Inspection | 180 | | 180 | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| Wait | 300 | | | 300 |
| OP 160 - Process (NDT, Alodine) | 2400 | 2400 | | |
| Wait | 33 | | | 33 |
| OP 170 - Inspection | 3 | | 3 | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| Wait | 110 | | | 110 |
| OP 20 - Assembly (Force Mate) | | | | |
| S/U | 5 | | 5 | |
| C/T | 10 | 10 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |

| Lean Supplier Upper Beam | | | | |
|---|---|---|---|---|
| **Process Step** | **Total Process Time** | **Value Added** | **Non-Value Added** | **Waste** |
| Wait | 165 | | | 165 |
| OP 121 - Bridgeport | | | | |
| S/U | 0 | | 0 | |
| C/T | 15 | 15 | | |
| Inspection | 5 | | 5 | |
| Wait | 220 | | | 220 |
| OP 123 - Bridgeport | | | | |
| S/U | 15 | | 15 | |
| C/T | 20 | 20 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 110 | | | 110 |
| OP 125 - Bridgeport | | | | |
| S/U | 20 | | 20 | |
| C/T | 10 | 10 | | |
| Inspection | 5 | | 5 | |
| Wait | 110 | | | 110 |
| OP 128 - Bridgeport | | | | |
| S/U | 10 | | 10 | |
| C/T | 10 | 10 | | |
| Inspection | 5 | | 5 | |
| Wait | 110 | | | 110 |
| OP 129 - Bridgeport | | | | |
| S/U | 10 | | 10 | |
| C/T | 10 | 10 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 15 | | | 15 |
| Wait | 300 | | | 300 |
| OP 130 - Deburr | | | | |
| C/T | 45 | | 45 | |
| Wait | 5 | | | 5 |
| Move | 15 | | | 15 |
| Wait | 445 | | | 445 |
| OP 140 - Inspection | | | | |
| S/U | 30 | | 30 | |
| C/T | 45 | 45 | | |
| OP 150 - Source Inspection | 180 | | 180 | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| Wait | 300 | | | 300 |
| OP 160 - Process (NDT, Alodine) | 2400 | 2400 | | |
| Wait | 33 | | | 33 |
| OP 170 - Inspection | 3 | | 3 | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| Wait | 110 | | | 110 |
| OP 20 - Assembly (Force Mate) | | | | |
| S/U | 5 | | 5 | |
| C/T | 10 | 10 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |

| Lean Supplier Upper Beam | | | | |
|---|---|---|---|---|
| **Process Step** | **Total Process Time** | **Value Added** | **Non-Value Added** | **Waste** |
| Move | 15 | | | |
| Wait | | | | |
| OP 25 - Bridgeport | | | | |
| S/U | 30 | | 30 | |
| C/T | 35 | 35 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 15 | | | 15 |
| Wait | 440 | | | 440 |
| OP 30 - Dixi | | | | |
| S/U | 30 | | 30 | |
| C/T | 40 | 40 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 15 | | | 15 |
| Wait | 55 | | | 55 |
| OP 70 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 15 | | | 15 |
| Wait | 330 | | | 330 |
| OP 80 - Deburr | 30 | | 30 | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| Wait | 165 | | | 165 |
| OP 90 - Final Inspection | | | | |
| S/U | 5 | | 5 | |
| C/T | 15 | 15 | | |
| Wait | 5 | | | 5 |
| Move | 15 | | | 15 |
| Wait | 440 | | | 440 |
| OP 110 - Assembly (Bushings) | | | | |
| S/U | 10 | | 10 | |
| C/T | 40 | 40 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 1 | | | 1 |
| Wait | 55 | | | 55 |
| OP 120 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |
| OP 130 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |

| Lean Supplier Upper Beam | | | | |
|---|---|---|---|---|
| **Process Step** | **Total Process Time** | **Value Added** | **Non-Value Added** | **Waste** |
| OP 140 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |
| OP 150 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |
| OP 160 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |
| OP 170 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |
| OP 180 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |
| OP 190 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |
| Move | 15 | | | 15 |
| Wait | 385 | | | 385 |
| OP 195 - Final Inspection | | | | |
| S/U | 15 | | 15 | |
| C/T | 35 | 35 | | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| Wait | 5 | | | 5 |
| OP 200 - Process (Alodine, Prime, Paint) | 2400 | 2400 | | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| Wait | 385 | | | 385 |
| OP 210 - Inspection | | | | |
| S/U | 40 | | 40 | |
| C/T | 35 | 35 | | |

| Lean Supplier Upper Beam | | | | |
|---|---|---|---|---|
| **Process Step** | **Total Process Time** | **Value Added** | **Non-Value Added** | **Waste** |
| Column | 2749 | 8590 | 2331 | 1653 |
| *Percentages* | | 31% | 8% | 60% |
| *Hours* | 458 | | | |
| *Days* | 46 | | | |
| *Calendar Days* | 64 | | | |

The VAST team represented the Lean technique of value stream mapping using VISIO software to help the supplier identify their manufacturing processes for the F/A-22 Link Arm. Data charts containing the raw calculations are also included.

| Lean Supplier<br>Calculation of Process Times for Link Arms | | | | |
|---|---|---|---|---|
| | Process Time | Value Added | Required Waste | Pure Waste |
| Part Numbers 915 - 918 | 21,076 | 5,882 | 1,375 | 13,819 |
| Total Process Times (Minutes) | 21,076 | 5,882 | 1,375 | 13,819 |
| ** all figures are in minutes* | | | | |
| Value Added as a percentage of Total Process Time | | 28% | | |
| Required Waste as a percentage of Total Process Time | | 7% | | |
| Pure Waste as a percentage of Total Process Time | | 66% | | |

| Lean Supplier<br>Link Arm Mapping | | | | |
|---|---|---|---|---|
| **Process Step** | **Total Process Time** | **Value Added** | **Non-Value Added** | **Waste** |
| Receive Material | | | | |
| Inspection | 10 | | 10 | |
| Move | 15 | | | 15 |
| Wait | 990 | | | 990 |
| OP 10 - Vertical Mazack | | | | |
| S/U | 150 | | 150 | |
| C/T | 90 | 90 | | |
| Wait | 90 | | | 90 |
| Move | 5 | | | 5 |
| Wait | 5058 | | | 5058 |
| OP 20 - Horizontal Mazak | | | | |
| S/U | 90 | | 90 | |
| C/T | 342 | 342 | | |
| Move | 1 | | | 1 |
| Wait | 5 | | | 5 |
| Inspection | 90 | | 90 | |
| Move | 1 | | | 1 |
| OP 30 - Horizontal Mazak | | | | |
| S/U | 60 | | 60 | |
| C/T | 84 | 84 | | |
| Move | 1 | | | 1 |
| Wait | 5 | | | 5 |
| Inspection | 60 | | 60 | |
| Move | 1 | | | 1 |
| OP 40 - Horizontal Mazak | | | | |
| S/U | 60 | | 60 | |
| C/T | 34 | 34 | | |
| Move | 1 | | | 1 |
| Wait | 5 | | | 5 |
| Inspection | 60 | | 60 | |
| Move | 15 | | | 15 |
| Wait | 55 | | | 55 |
| OP 50 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 1 | | | 1 |
| Wait | 55 | | | 55 |
| OP 60 - Bridgeport | | | | |
| S/U | 15 | | 15 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 15 | | | 15 |
| Wait | 1650 | | | 1650 |
| Wait | 300 | | | 300 |
| OP 70 - Deburring | | | | |
| C/T | 150 | 150 | | |

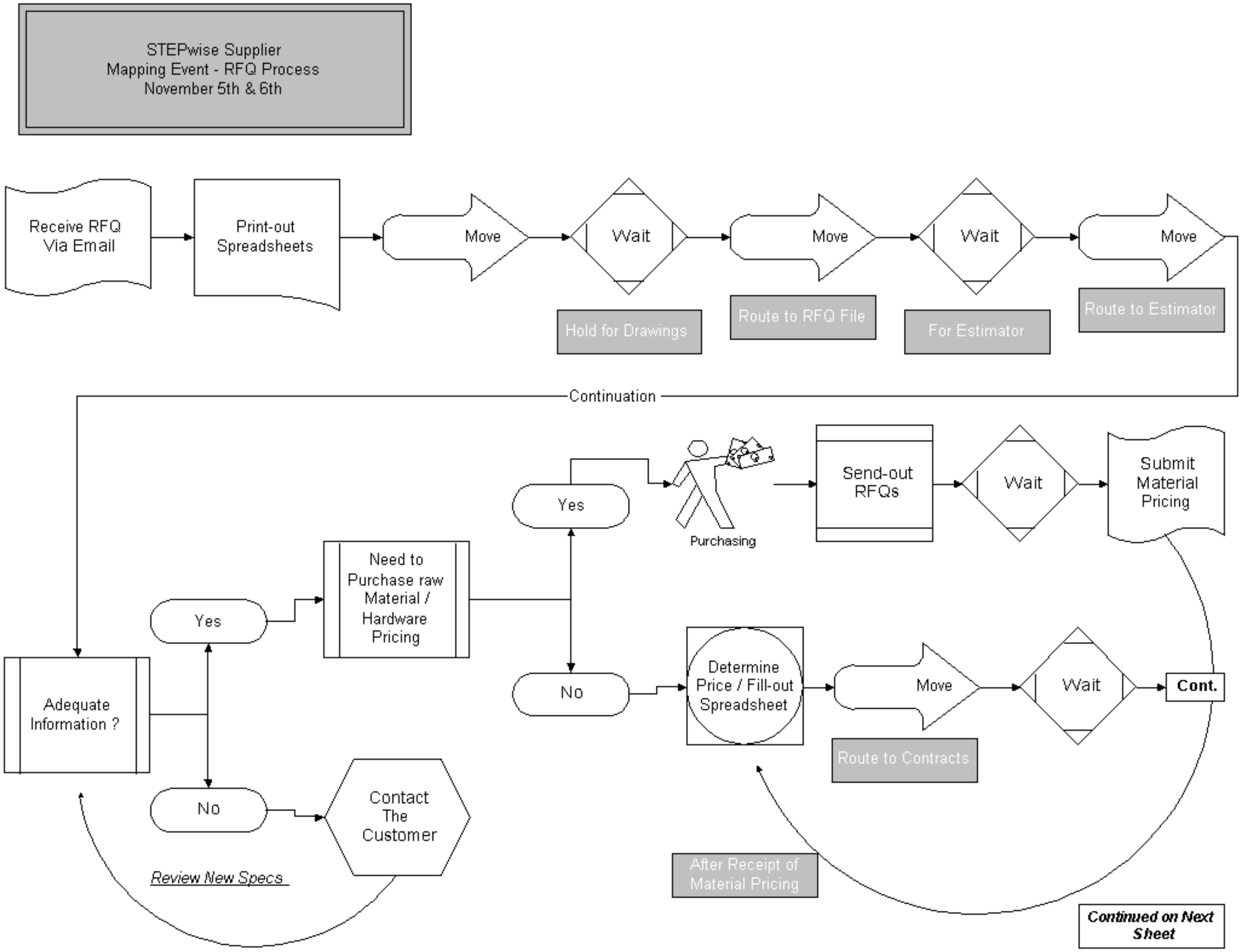
| Lean Supplier<br>Link Arm Mapping | | | | |
|---|---|---|---|---|
| **Process Step** | **Total Process Time** | **Value Added** | **Non-Value Added** | **Waste** |
| Move | 1 | | | 1 |
| Wait | 5 | | | 5 |
| OP 210 - Final Inspection | 15 | | 15 | |
| Wait | 60 | | | 60 |
| OP 215 - Source Inspection | | | | |
| C/T | 60 | | 60 | |
| Move | 1 | | | 1 |
| Wait | 300 | | | 300 |
| OP 220 - Process (Alodine,Prime, NDT) | | | | |
| C/T | 2400 | 2400 | | |
| Wait | 5 | | | 5 |
| OP 270 - Inspection | 3 | | 3 | |
| Move | 1 | | | 1 |
| Wait | 22 | | | 22 |
| OP 25 - Assembly - Helical Inserts | | | | |
| S/U | 5 | | 5 | |
| C/T | 2 | 2 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 220 | | | 220 |
| | | | | |
| OP 26 - Assembly - Rivet the cover | | | | |
| S/U | 5 | | 5 | |
| C/T | 20 | 20 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 1 | | | 1 |
| Wait | 165 | | | 165 |
| OP 27 - Bridgeport | | | | |
| S/U | 45 | | 45 | |
| C/T | 15 | 15 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 1 | | | 1 |
| Wait | 77 | | | 77 |
| OP 30 - Assembly - Install Forcemate | | | | |
| S/U | 5 | | 5 | |
| C/T | 7 | 7 | | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| Inspection | 5 | | 5 | |
| Move | 15 | | | 15 |
| Wait | 1452 | | | 1452 |
| OP 50 - DIXI | | | | |
| S/U | 240 | | 240 | |
| C/T | 132 | 132 | | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| Inspection | 45 | | 45 | |
| Move | 15 | | | 15 |
| Wait | 15 | | | 15 |

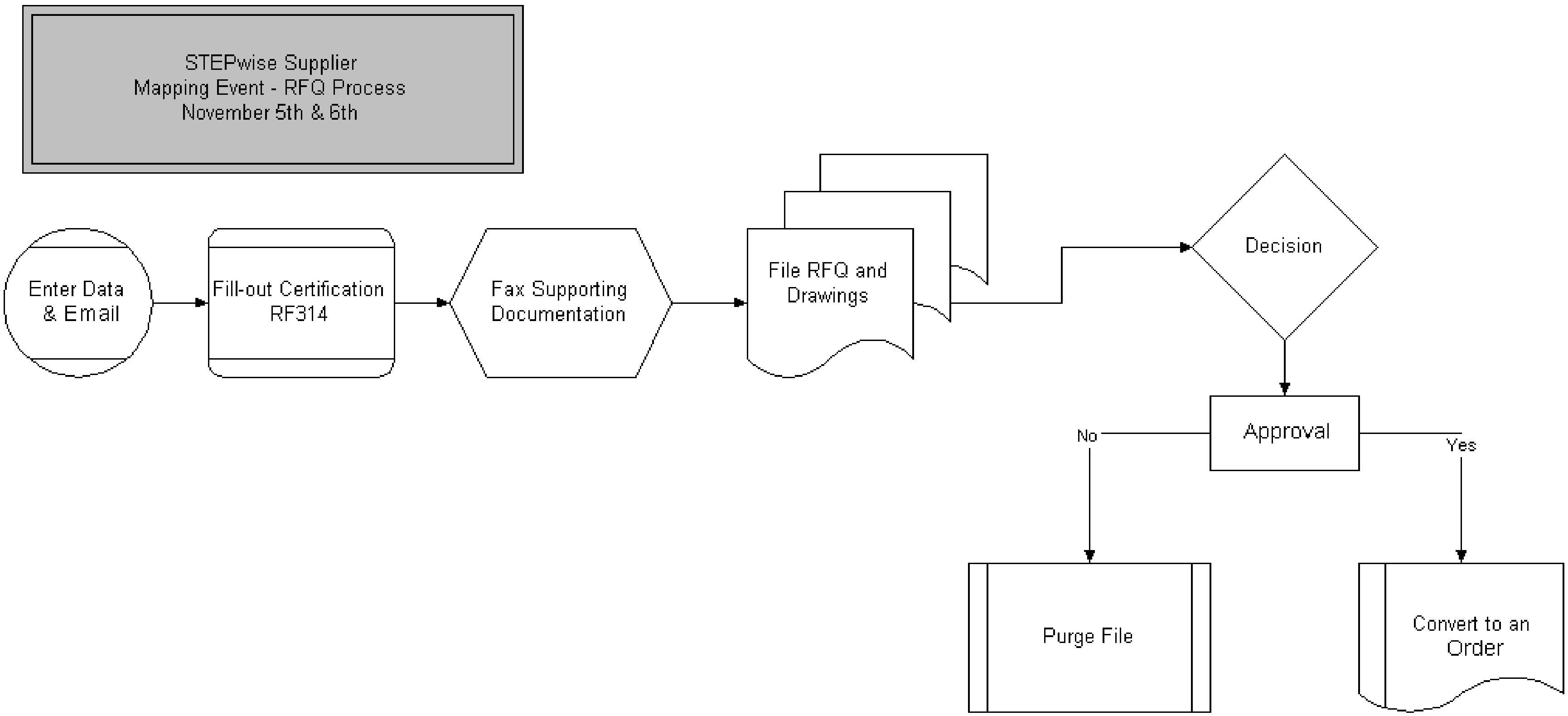
| Lean Supplier<br>Link Arm Mapping | | | | |
|---|---|---|---|---|
| **Process Step** | **Total Process Time** | **Value Added** | **Non-Value Added** | **Waste** |
| OP 52 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |
| OP 54 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |
| OP 56 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| OP 60 - Process - Alodine | | | | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 110 | | | 110 |
| OP 70 - Assembly - Bushings | | | | |
| S/U | 10 | | 10 | |
| C/T | 10 | 10 | | |
| Wait | 22 | | | 22 |
| OP 80 - Assembly - Screw inserts | | | | |
| S/U | 5 | | 5 | |
| C/T | 2 | 2 | | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| Wait | 495 | | | 495 |
| OP 90 - Inspection - Key Char | | | | |
| C/T | 45 | | 45 | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| Wait | 165 | | | 165 |
| OP 110 - Bridgeport | | | | |
| S/U | 10 | | 10 | |
| C/T | 15 | 15 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 165 | | | 165 |
| OP 120 - Brdigeport | | | | |
| S/U | 10 | | 10 | |
| C/T | 15 | 15 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 165 | | | 165 |
| OP 130 - Bridgeport | | | | |
| S/U | 10 | | 10 | |
| C/T | 15 | 15 | | |

| Lean Supplier<br>Link Arm Mapping | | | | |
|---|---|---|---|---|
| **Process Step** | **Total Process Time** | **Value Added** | **Non-Value Added** | **Waste** |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 1 | | | 1 |
| Wait | 55 | | | 55 |
| OP 140 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |
| OP 150 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |
| OP 160 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |
| OP 170 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 15 | | | 15 |
| Wait | 132 | | | 132 |
| OP 180 - Rambaudi | | | | |
| S/U | 30 | | 30 | |
| C/T | 12 | 12 | | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| Inspection | 5 | | 5 | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| Wait | 132 | | | 132 |
| OP 190 - Rambaudi - Mill | | | | |
| S/U | 30 | | 30 | |
| C/T | 12 | 12 | | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| Inspection | 5 | | 5 | |
| Move | 1 | | | 1 |
| Wait | 825 | | | 825 |
| OP 200 - Deburring | 75 | 75 | | |
| Wait | 5 | | | 5 |
| Move | 15 | | | 15 |
| Wait | 5 | | | 5 |
| OP 210 - Inspection | 60 | | 60 | |
| Move | 1 | | | 1 |

| Lean Supplier<br>Link Arm Mapping | | | | |
|---|---|---|---|---|
| **Process Step** | **Total Process Time** | **Value Added** | **Non-Value Added** | **Waste** |
| Wait | 300 | | | 300 |
| OP 220 - Process (Paint) | 2400 | 2400 | | |
| Wait | 187 | | | 187 |
| OP 230 - Inspection | 17 | | 17 | |
| Column Totals | 21076 | 5882 | 1375 | 13819 |
| *Percentages* | | 28% | 7% | 66% |
| *Hours* | 351 | | | |
| *Days* | 35 | | | |
| *Calendar Days* | 49 | | | |

The VAST team used the same Lean technique of value stream mapping to help the STEPwise supplier identify their internal review processes for request for quotes (RFQs) requests.

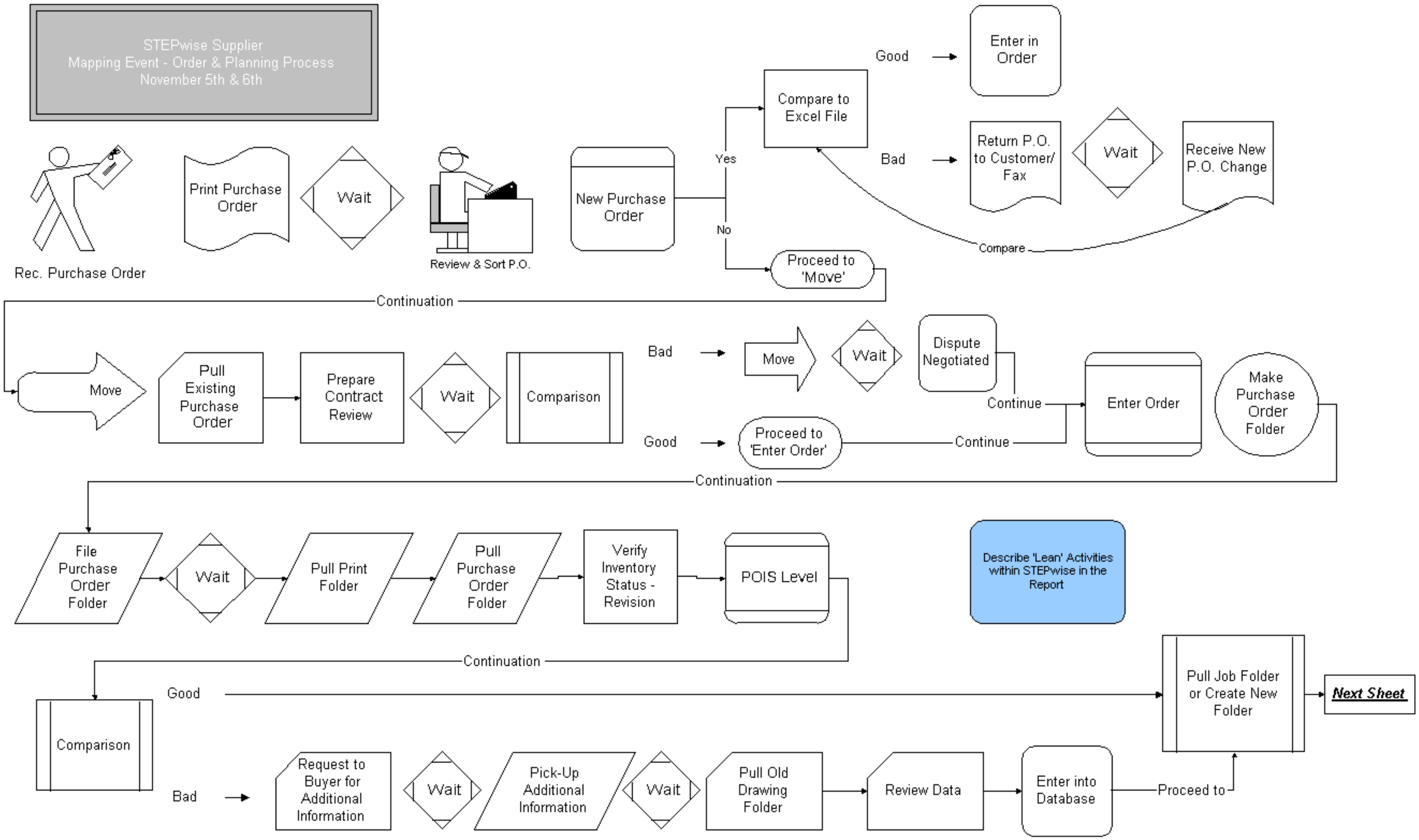

STEPwise Supplier
Mapping Event - RFQ Process
November 5th & 6th
Receive RFQ Via Email
Print-out Spreadsheets
Move
Wait
Move
Wait
Move
Hold for Drawings
Route to RFQ File
For Estimator
Route to Estimator
Continuation
Adequate Information ?
Yes
No
Need to Purchase raw Material / Hardware Pricing
Contact The Customer
Review New Specs
Yes
No
Purchasing
Send-out RFQs
Wait
Submit Material Pricing
Determine Price / Fill-out Spreadsheet
Move
Wait
Cont.
Route to Contracts
After Receipt of Material Pricing
Continued on Next Sheet

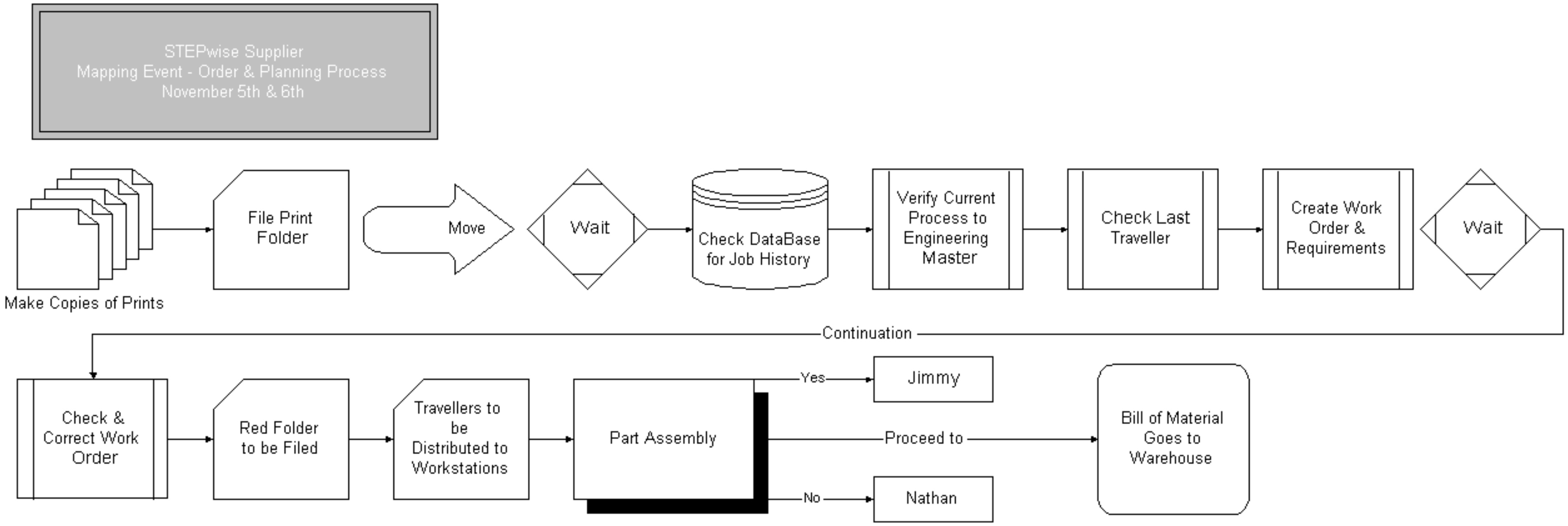

STEPwise Supplier
Mapping Event - RFQ Process
November 5th & 6th
Enter Data & Email
Fill-out Certification RF314
Fax Supporting Documentation
File RFQ and Drawings
Decision
Approval
No
Yes
Purge File
Convert to an Order

| STEPwise Supplier<br>Request for Proposal Process Analysis | | | |
|---|---|---|---|
| **Operation** | **Department** | **Description** | **Process Time** |
| 1 | CON | RECEIVE RFQ | 1 |
| 2 | CON | PRINT | 1 |
| 3 | CON | TO OPEN RFQ FILE | 1 |
| 4 | CON | WAIT FOR DWGS | 2880 |
| 5 | CON | RECEIVE DRAWINGS | 1 |
| 6 | CON | TO FILE W/ RFQ | 1 |
| 7 | CON | WAIT FOR ESTIMATOR | 1440 |
| 8 | EST | TO ESTIMATING | 5 |
| 9 | EST | ADEQUATE INFO? | 60 |
| | | V NO V | |
| 10 | EST | GO TO CON / WAIT FOR DWGS | 20 |
| 11 | CON | WAIT FOR DWGS | 2880 |
| 12 | CON | RECEIVE DWGS | 1 |
| 13 | CON | PULL SPECIFICATIONS | 20 |
| 16 | EST | NEED OUTSIDE PRICING? | 20 |
| | | V YES V | |
| 17 | EST | TO PURCHASING | 5 |
| 18 | PUR | SEND RFQ | 20 |
| 19 | PUR | WAIT FOR RESPONSE | 5760 |
| 20 | PUR | SUBMIT TO ESTIMATING | 5 |
| 21 | EST | DETERMINE PRICE | 360 |
| 22 | EST | TO CONTRACTS | 5 |
| 23 | CON | FILL OUT FORM AND SUBMIT | 25 |
| 24 | CON | FILE DWGS UPSTAIRS | 10 |
| 25 | CON | ENTER IN DATABASE | 3 |
| 26 | CON | TO QUOTE FILE | 1 |
| | | **PROCESS TOTAL (minutes)** | **13,525** |
| | | **Hours** | **225** |

| STEPwise Supplier<br>Request for Proposal Process Analysis Using STEPwise Tools | | | |
|---|---|---|---|
| **Operation** | **Department** | **Description** | **Process Time** |
| 1 | CON | RECEIVE RFQ | 1 |
| 2 | CON | DOWNLOAD FILES | 15 |
| 3 | CON | IMPORT FILES | 15 |
| 4 | CON | WAIT FOR ESTIMATOR | 1440 |
| 5 | EST | ADEQUATE INFO? | 20 |
| 6 | CON | NEED OUTSIDE PRICING? | 20 |
| 7 | EST | TO PURCHASING | 5 |
| 8 | PUR | SEND RFQ | 20 |
| 9 | PUR | WAIT FOR RESPONSE | 5760 |
| 10 | PUR | SUBMIT TO ESTIMATING | 5 |
| 11 | EST | DETERMINE PRICE | 240 |
| 12 | CON | FILL OUT FORM AND SUBMIT | 10 |
| 13 | CON | ENTER IN DATABASE | 3 |
| 14 | CON | TO QUOTE FILE | 3 |
| | | **PROCESS TOTAL (minutes)** | **7,557** |
| | | **Hours** | **126** |

The VAST team used the same Lean technique of value stream mapping to help the STEPwise supplier identify their internal review processes for purchase order (POs).


STEPwise Supplier
Mapping Event - Order & Planning Process
November 5th & 6th
Rec. Purchase Order
Print Purchase Order
Wait
Review & Sort P.O.
New Purchase Order
Yes
No
Compare to Excel File
Good
Enter in Order
Bad
Return P.O. to Customer/ Fax
Wait
Receive New P.O. Change
Compare
Proceed to 'Move'
Continuation
Move
Pull Existing Purchase Order
Prepare Contract Review
Wait
Comparison
Bad
Move
Wait
Dispute Negotiated
Continue
Good
Proceed to 'Enter Order'
Continue
Enter Order
Make Purchase Order Folder
Continuation
File Purchase Order Folder
Wait
Pull Print Folder
Pull Purchase Order Folder
Verify Inventory Status - Revision
POIS Level
Describe 'Lean' Activities within STEPwise in the Report
Continuation
Comparison
Good
Pull Job Folder or Create New Folder
Next Sheet
Bad
Request to Buyer for Additional Information
Wait
Pick-Up Additional Information
Wait
Pull Old Drawing Folder
Review Data
Enter into Database
Proceed to


STEPwise Supplier
Mapping Event - Order & Planning Process
November 5th & 6th
Make Copies of Prints
File Print Folder
Move
Wait
Check DataBase for Job History
Verify Current Process to Engineering Master
Check Last Traveller
Create Work Order & Requirements
Wait
Continuation
Check & Correct Work Order
Red Folder to be Filed
Travellers to be Distributed to Workstations
Part Assembly
Yes
Jimmy
Proceed to
No
Nathan
Bill of Material Goes to Warehouse

| STEPwise Supplier<br>Purchase Order Process Analysis | | | |
|---|---|---|---|
| **Operation** | **Department** | **Description** | **Process Time** |
| 1 | CONT | PRINT PO | 5 |
| 2 | CONT | WAIT FOR CONTRACTS | 60 |
| 3 | CONT | REVIEW / SORT | 2 |
| 4 | CONT | NEW PO? | 1 |
| | | V NO V | |
| 5 | CONT | PULL PO | 3 |
| 6 | CONT | PREPARE CONTRCT WKSHT | 4 |
| 7 | CONT | WAIT | 1440 |
| 8 | CONT | REVIEW | 15 |
| 9 | CONT | ACCEPTABLE? | |
| | | V YES V | |
| 10 | CONT | ENTER ORDER IN DATABASE | 5 |
| 11 | CONT | MAKE PO FOLDER | 2 |
| 12 | CONT | FILE | 2 |
| 13 | | WAIT FOR LT WINDOW | |
| 14 | PLN | PULL PRINT | 2405 |
| 14a | PLN | *PULL PRINT* | 0 |
| 14b | PLN | *NO PRINT* | 0 |
| 15 | PLN | PULL PO | 3 |
| 16 | PLN | VERIFY REV'S. OK? | 7 |
| | | V NO V | |
| 17 | CONT | REQUEST INFO FROM BUYER | 10 |
| 18 | CONT | WAIT FOR CORRECT INFO | 4320 |
| 19 | PLN | P/U PRINTS FROM BUYER | 90 |
| 20 | PLN | WAIT FOR DOC CTRL | 120 |
| 21 | PLN | PULL DWG FOLDER | 5 |
| 22 | PLN | VALIDATING LM AERO INFO | 7 |
| | | V YES V | |
| 23 | PLN | CHECK INVENTORY. STK? | 1 |
| | | V NO V | |
| 24 | | GO TO OP# 25 | |
| | | V NO V | 10 |
| 25 | PLN | PULL JOB OR CREATE | 2 |
| 26 | PLN | COPY PRINT, PO | 30 |
| 27 | PLN | FILE PRINT | 1 |
| 28 | PLN | FILE PO | 1 |
| 29 | PLN | WAIT FOR PLANNER | 4320 |
| 30 | PLN | JOB HISTORY EXISTS? | 2 |
| | | V YES V | |
| 31 | PLN | REVIEW ENG MASTER, CHGS | 10 |
| 31a | PLN | BUILD NEW ENG MASTER | 60 |
| 31b | PLN | LOOKING FOR SPECS | 10 |
| 31c | PLN | READING THE SPECS | 15 |
| 31d | PLN | PULLING MASTER TOGEHER | 35 |
| 31e | PLN | NON-MILL SPECS | 5 |
| 31f | PLN | WAITING FOR C-SPECS | 240 |
| 32 | PLN | CREATE W/O | 5 |
| 33 | PLN | DISTRIBUTE, FILE | 10 |
| | | **Process Total (Minutes)** | **13263** |
| | | **Hours** | **221** |

| STEPwise Supplier<br>Purchase Order Process Analysis | | | |
|---|---|---|---|
| **Operation** | **Department** | **Description** | **Process Time** |
| 1 | CONT | PRINT PO | 5 |
| 2 | CONT | WAIT FOR CONTRACTS | 60 |
| 3 | CONT | REVIEW / SORT | 2 |
| 4 | CONT | NEW PO? | 1 |
| | | V NO V | |
| 5 | CONT | PULL PO | 3 |
| 6 | CONT | PREPARE CONTRCT WKSHT | 4 |
| 7 | CONT | WAIT | 1440 |
| 8 | CONT | REVIEW | 15 |
| 9 | CONT | ACCEPTABLE? | |
| | | V YES V | |
| 10 | CONT | ENTER ORDER IN DATABASE | 5 |
| 11 | CONT | MAKE PO FOLDER | 2 |
| 12 | CONT | FILE | 2 |
| 13 | | WAIT FOR LT WINDOW | |
| 14 | PLN | PULL PRINT | 0 |
| 14a | PLN | *PULL PRINT* | 0 |
| 14b | PLN | *NO PRINT* | 0 |
| 15 | PLN | PULL PO | 3 |
| 16 | PLN | VERIFY REV'S. OK? | 7 |
| | | V NO V | 1371 |
| 17 | CONT | REQUEST INFO FROM BUYER | 0 |
| 18 | CONT | WAIT FOR CORRECT INFO | 0 |
| 19 | PLN | P/U PRINTS FROM BUYER | 0 |
| 20 | PLN | WAIT FOR DOC CTRL | 0 |
| 21 | PLN | PULL DWG FOLDER | 0 |
| 22 | PLN | VALIDATING LM AERO INFO | 7 |
| | | V YES V | |
| 23 | PLN | CHECK INVENTORY. STK? | 1 |
| | | V NO V | |
| 24 | | GO TO OP# 25 | |
| | | V NO V | 10 |
| 25 | PLN | PULL JOB OR CREATE | 2 |
| 26 | PLN | COPY PRINT, PO | 30 |
| 27 | PLN | FILE PRINT | 1 |
| 28 | PLN | FILE PO | 1 |
| 29 | PLN | WAIT FOR PLANNER | 4320 |
| 30 | PLN | JOB HISTORY EXISTS? | 2 |
| | | V YES V | |
| 31 | PLN | REVIEW ENG MASTER, CHGS | 10 |
| 31a | PLN | BUILD NEW ENG MASTER | 60 |
| 31b | PLN | LOOKING FOR SPECS | 0 |
| 31c | PLN | READING THE SPECS | 0 |
| 31d | PLN | PULLING MASTER TOGEHER | 0 |
| 31e | PLN | NON-MILL SPECS | 0 |
| 31f | PLN | WAITING FOR C-SPECS | 0 |
| 32 | PLN | CREATE W/O | 5 |
| 33 | PLN | DISTRIBUTE, FILE | 10 |
| | | **Process Total (Minutes)** | **7379** |
| | | **Hours** | **123** |

The VAST team represented the Lean technique of value stream mapping using VISIO software to help the supplier identify their manufacturing processes for the F/A-22 Link Arm. Data charts containing the raw calculations are also included.

| Lean Supplier<br>Calculation of Process Times for Link Arms | | | | |
|---|---|---|---|---|
| | Process Time | Value Added | Required Waste | Pure Waste |
| Part Numbers 915 - 918 | 21,076 | 5,882 | 1,375 | 13,819 |
| Total Process Times (Minutes) | 21,076 | 5,882 | 1,375 | 13,819 |
| ** all figures are in minutes* | | | | |
| Value Added as a percentage of Total Process Time | | 28% | | |
| Required Waste as a percentage of Total Process Time | | 7% | | |
| Pure Waste as a percentage of Total Process Time | | 66% | | |

| Lean Supplier<br>Link Arm Mapping | | | | |
|---|---|---|---|---|
| **Process Step** | **Total Process Time** | **Value Added** | **Non-Value Added** | **Waste** |
| Receive Material | | | | |
| Inspection | 10 | | 10 | |
| Move | 15 | | | 15 |
| Wait | 990 | | | 990 |
| OP 10 - Vertical Mazack | | | | |
| S/U | 150 | | 150 | |
| C/T | 90 | 90 | | |
| Wait | 90 | | | 90 |
| Move | 5 | | | 5 |
| Wait | 5058 | | | 5058 |
| OP 20 - Horizontal Mazak | | | | |
| S/U | 90 | | 90 | |
| C/T | 342 | 342 | | |
| Move | 1 | | | 1 |
| Wait | 5 | | | 5 |
| Inspection | 90 | | 90 | |
| Move | 1 | | | 1 |
| OP 30 - Horizontal Mazak | | | | |
| S/U | 60 | | 60 | |
| C/T | 84 | 84 | | |
| Move | 1 | | | 1 |
| Wait | 5 | | | 5 |
| Inspection | 60 | | 60 | |
| Move | 1 | | | 1 |
| OP 40 - Horizontal Mazak | | | | |
| S/U | 60 | | 60 | |
| C/T | 34 | 34 | | |
| Move | 1 | | | 1 |
| Wait | 5 | | | 5 |
| Inspection | 60 | | 60 | |
| Move | 15 | | | 15 |
| Wait | 55 | | | 55 |
| OP 50 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 1 | | | 1 |
| Wait | 55 | | | 55 |
| OP 60 - Bridgeport | | | | |
| S/U | 15 | | 15 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 15 | | | 15 |
| Wait | 1650 | | | 1650 |
| Wait | 300 | | | 300 |
| OP 70 - Deburring | | | | |
| C/T | 150 | 150 | | |

| Lean Supplier<br>Link Arm Mapping | | | | |
|---|---|---|---|---|
| **Process Step** | **Total Process Time** | **Value Added** | **Non-Value Added** | **Waste** |
| Move | 1 | | | 1 |
| Wait | 5 | | | 5 |
| OP 210 - Final Inspection | 15 | | 15 | |
| Wait | 60 | | | 60 |
| OP 215 - Source Inspection | | | | |
| C/T | 60 | | 60 | |
| Move | 1 | | | 1 |
| Wait | 300 | | | 300 |
| OP 220 - Process (Alodine,Prime, NDT) | | | | |
| C/T | 2400 | 2400 | | |
| Wait | 5 | | | 5 |
| OP 270 - Inspection | 3 | | 3 | |
| Move | 1 | | | 1 |
| Wait | 22 | | | 22 |
| OP 25 - Assembly - Helical Inserts | | | | |
| S/U | 5 | | 5 | |
| C/T | 2 | 2 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 220 | | | 220 |
| OP 26 - Assembly - Rivet the cover | | | | |
| S/U | 5 | | 5 | |
| C/T | 20 | 20 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 1 | | | 1 |
| Wait | 165 | | | 165 |
| OP 27 - Bridgeport | | | | |
| S/U | 45 | | 45 | |
| C/T | 15 | 15 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 1 | | | 1 |
| Wait | 77 | | | 77 |
| OP 30 - Assembly - Install Forcemate | | | | |
| S/U | 5 | | 5 | |
| C/T | 7 | 7 | | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| Inspection | 5 | | 5 | |
| Move | 15 | | | 15 |
| Wait | 1452 | | | 1452 |
| OP 50 - DIXI | | | | |
| S/U | 240 | | 240 | |
| C/T | 132 | 132 | | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| Inspection | 45 | | 45 | |
| Move | 15 | | | 15 |
| Wait | 15 | | | 15 |

| Lean Supplier<br>Link Arm Mapping | | | | |
|---|---|---|---|---|
| **Process Step** | **Total Process Time** | **Value Added** | **Non-Value Added** | **Waste** |
| OP 52 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |
| OP 54 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |
| OP 56 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| OP 60 - Process - Alodine | | | | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 110 | | | 110 |
| OP 70 - Assembly - Bushings | | | | |
| S/U | 10 | | 10 | |
| C/T | 10 | 10 | | |
| Wait | 22 | | | 22 |
| OP 80 - Assembly - Screw inserts | | | | |
| S/U | 5 | | 5 | |
| C/T | 2 | 2 | | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| Wait | 495 | | | 495 |
| OP 90 - Inspection - Key Char | | | | |
| C/T | 45 | | 45 | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| Wait | 165 | | | 165 |
| OP 110 - Bridgeport | | | | |
| S/U | 10 | | 10 | |
| C/T | 15 | 15 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 165 | | | 165 |
| OP 120 - Brdigeport | | | | |
| S/U | 10 | | 10 | |
| C/T | 15 | 15 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 165 | | | 165 |
| OP 130 - Bridgeport | | | | |
| S/U | 10 | | 10 | |
| C/T | 15 | 15 | | |

| Lean Supplier<br>Link Arm Mapping | | | | |
|---|---|---|---|---|
| **Process Step** | **Total Process Time** | **Value Added** | **Non-Value Added** | **Waste** |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 1 | | | 1 |
| Wait | 55 | | | 55 |
| OP 140 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |
| OP 150 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |
| OP 160 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Wait | 55 | | | 55 |
| OP 170 - Honing | | | | |
| S/U | 5 | | 5 | |
| C/T | 5 | 5 | | |
| Wait | 5 | | | 5 |
| Inspection | 5 | | 5 | |
| Move | 15 | | | 15 |
| Wait | 132 | | | 132 |
| OP 180 - Rambaudi | | | | |
| S/U | 30 | | 30 | |
| C/T | 12 | 12 | | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| Inspection | 5 | | 5 | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| Wait | 132 | | | 132 |
| OP 190 - Rambaudi - Mill | | | | |
| S/U | 30 | | 30 | |
| C/T | 12 | 12 | | |
| Wait | 5 | | | 5 |
| Move | 1 | | | 1 |
| Inspection | 5 | | 5 | |
| Move | 1 | | | 1 |
| Wait | 825 | | | 825 |
| OP 200 - Deburring | 75 | 75 | | |
| Wait | 5 | | | 5 |
| Move | 15 | | | 15 |
| Wait | 5 | | | 5 |
| OP 210 - Inspection | 60 | | 60 | |
| Move | 1 | | | 1 |

| Lean Supplier<br>Link Arm Mapping | | | | |
|---|---|---|---|---|
| **Process Step** | **Total Process Time** | **Value Added** | **Non-Value Added** | **Waste** |
| Wait | 300 | | | 300 |
| OP 220 - Process (Paint) | 2400 | 2400 | | |
| Wait | 187 | | | 187 |
| OP 230 - Inspection | 17 | | 17 | |
| Column Totals | 21076 | 5882 | 1375 | 13819 |
| *Percentages* | | 28% | 7% | 66% |
| *Hours* | 351 | | | |
| *Days* | 35 | | | |
| *Calendar Days* | 49 | | | |